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Comparative outcomes of proximal femur intramedullary nailing vs. cemented bipolar hemiarthroplasty for treating intertrochanteric fractures in patients aged 75 and older: analysis of risk factors for postoperative all-cause mortality

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Abstract

Background As the population continues to age, the occurrence of intertrochanteric femoral fractures (IFFs) has steadily increased. The main aims of this investigation were to evaluate and compare the clinical outcomes, ambulatory ability, overall survival, and all-cause mortality between two cephalic screws combined with compression proximal-femoral intramedullary nailing internal fixation (IF) and long-stemmed cemented bipolar hemiarthroplasty (LCHA) in patients aged 75 years and older. The secondary objective was to investigate the relative independent risk factors contributing to postoperative all-cause mortality.

Methods A retrospective analysis was conducted on 251 elderly patients with IFF who underwent IF or LCHA between January 2018 and October 2022. We employed generalized estimation equations along with univariate and multivariate analyses to examine the impact of various surgical interventions and other pertinent factors on postoperative ambulatory ability and all-cause mortality outcomes. Associations between sex, age, number of comorbidities, aspartate aminotransferase (AST) levels, total blood transfusions, and mortality were analyzed via Cox proportional hazards models.

Results The analysis included a cohort of 120 patients from the IF group and 121 patients from the LCHA group. Statistically significant differences were not observed in the clinical outcomes, ambulatory ability, overall survival, or all-cause mortality after surgical treatment between the groups receiving IF and LCHA ($p > 0.05$). Nevertheless, among patients aged ≥ 85 years, the IF group demonstrated a lower rate of all-cause mortality than the LCHA group did ($p < 0.05$). As age increases and the number of preoperative comorbidities and the amount of perioperative

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transfusion increase, the preoperative AST level decreases, which is associated with a greater risk of postoperative death. ($p < 0.05$).

Conclusions In elderly patients aged 75–84 years with intertrochanteric femur fractures, both internal fixation (IF) and long-stemmed cemented hemiarthroplasty (LCHA) are viable treatment options. However, for patients aged 85 years and older, IF is associated with a relatively lower postoperative all-cause mortality rate and should be prioritized as a treatment modality. Additionally, preoperative AST levels may serve as a valuable predictor of postoperative all-cause mortality in elderly patients undergoing surgery for intertrochanteric femur fractures.

Keywords Hemarthroplasty, Intramedullary fixation, Intertrochanteric femoral fractures

Background

As the population continues to age, the occurrence of intertrochanteric femoral fractures (IFFs) has been steadily increasing. Consequently, treatment- and nursing-associated costs represent a substantial medical burden, warranting significant attention from the medical community [1]. Presently, the primary surgical treatment modality for IFF is intramedullary nailing fixation [2, 3]. Since the 1970s, hip arthroplasty has been considered a potential substitute approach for managing IFF [4]. However, recent research has highlighted primary cemented hemiarthroplasty as a viable treatment option for IFF [5–9].

To our knowledge, few studies have compared the effects of age restrictions of 75 years or older in the context of a comparative study between two cephalic screws combined with compression proximal-femur intramedullary nailing internal fixation (IF) for the IFF and long-stemmed cemented bipolar hemiarthroplasty (LCHA). The main aims of this investigation were to assess and compare the clinical outcomes, ambulatory ability, overall survival, and all-cause mortality between the two treatment approaches in older patients aged 75 years or older. Additionally, the secondary objective of this investigation was to ascertain the independent risk factors associated with postoperative mortality.

Methods

Our Institutional Ethics Review Board approved this study. Between January 2018 and October 2022, 251 consecutive adult patients aged 75 years or older with IFF fulfilled the inclusion criteria for this retrospective study. The patients were presented with both treatment alternatives and received a detailed description of potential surgical complications and related risks, which was provided by an attending physician rather than a senior surgeon. Patients were subsequently granted the autonomy to make an informed decision regarding their preferred treatment approach. Before the operation, the patient and their family provided informed consent by signing a consent form. Among them, 126 received IF treatment by Orthmed Changzhou, China, after achieving a closed reduction. The remaining 125 patients were treated with LCHA by Beijing AK MEDICAL. The following exclusion criteria were applied to patients: (1) were under 75 years of age; (2) had tumors or pathological fractures; (3) had multiple traumas or fractures; (4) had open fractures, in which other parts of the body continued to bleed, such as splenic rupture or gastrointestinal bleeding; (5) had blood system diseases or severe anemia before surgery; (6) had coagulation dysfunction; (7) had mental disorders; (8) had epilepsy; and (9) were lost to follow-up. Six patients in the IF treatment group and four patients in the LCHA treatment group were unable to be followed up. The requisite data were obtained from the hospital information system, comprising patients' demographic details, blood test data, imaging data, transthoracic echocardiography findings (left ventricular ejection fraction, LVEF), ultrasonography findings of blood vessels of both lower limbs, anesthesia details, surgical details, information on blood transfusions during hospitalization, and preexisting comorbidities. The comorbidities considered included diseases of the circulatory system (hypertension, heart disease, etc.), respiratory diseases, chronic gastritis, diabetes mellitus, Alzheimer's disease, and Parkinson's disease. Anesthetic and surgical risks were evaluated preoperatively via the American Society of Anesthesiologists (ASA) score. Patients underwent dual-energy X-ray absorptiometry, which indicated the presence of osteoporosis. Fracture classification (OTA/AO-2018) was performed by two senior surgeons (YD, Z-M T) and a radiologist (G-H L) after reviewing the injury radiographs [10] (Table 1).

Surgical techniques

All surgical interventions were performed by experienced surgeons with substantial expertise at the Orthopedic Department of our hospital. All patients included in the LCHA group underwent surgical intervention via the modified Gibson approach under either spinal or general anesthesia after a sterile environment was established. The procedure involved exposing the hip joint and removing the femoral head through an osteotomy at the base of the femoral neck. The femoral medullary cavity was then filled with bone cement (Heraeus Medical GmbH). A cemented femoral long stem (Beijing AK

Table 1 AO/OTA-2018 classification of 241 intertrochanteric fractures

AO/OTA-2018 classification	IF group (*n* = 120) (%)	LCHA group (*n* = 121) (%)
31A1-2	20 (16.7%)	24 (19.8%)
31A1-3	20 (16.7%)	16 (13.2%)
31A2-2	35 (29.2%)	43 (35.5%)
31A2-3	23 (19.2%)	34 (28.1%)
31A3-1	1 (0.8%)	0 (0%)
31A3-2	2 (1.6%)	0 (0%)
31A3-3	19 (15.8%)	4 (3.3%)

Note: Frequencies (%)

Abbreviations: AO/OTA, Association for the Study of Interfixation-American Orthopedic Trauma Association; IF, two cephalic screws combined with compression proximal-femur intramedullary nailing internal fixation; LCHA, long-stemmed cemented bipolar hemiarthroplasty

MEDICAL) was implanted expediently (Fig. 1). Following intertrochanteric fracture reduction, stabilization was achieved by applying a wire tension band via a kerf pin. For type 31A3 fractures, the lateral wall was fixed via a locking plate. After the femoral head prosthesis was implanted, the congruency of the relocated hip joint was assessed, and the bipolar cup was securely fixed. In the IF group, the main screw (Orthmed, Changzhou, China) was carefully inserted. The appropriate-length tension screw was subsequently screwed in, followed by a combination of compression screws and a distal locking screw.

Patient assessment

In accordance with the guidelines provided by the Chinese National Ministry of Health on red blood cell transfusion, the criteria include either a hemoglobin level less than 70 g/L or a hemoglobin level ranging from 70 to 100 g/L with symptomatic anemia [11]. The calculations were carried out via the "hemoglobin balance method" [12–14]. Follow-up evaluations were scheduled at specific intervals, including 3, 6, 9, and 12 months postoperatively and annually until study completion. During the postoperative follow-up period, patients or their family members were interviewed to evaluate the postoperative ambulatory ability, employing Koval's grades as the assessment tool [15] (Table 2). In the event of mortality, the date of death was recorded.

Table 2 Grading of ambulatory ability

Category	Definition
I	Independent community ambulators
II	Community ambulators with cane
III	Community ambulators with crutch or walker
IV	Independent household ambulators
V	Household ambulators with cane
VI	Household ambulators with crutch or walker
VII	Nonfunctional ambulators

Note: From Koval et al. [15]

Statistical analysis

Differences in clinical features between the IF and LCHA groups were examined via independent sample t tests (normally distributed data), Mann–Whitney U tests (nonnormally distributed data), chi-square tests (classified variables), and Wilcoxon rank sum tests (ordinal multinomial variables). Our study utilized the Kaplan–Meier method to analyze overall survival. This study presented an analysis of the baseline characteristics of the IF and LCHA groups, indicating significant differences

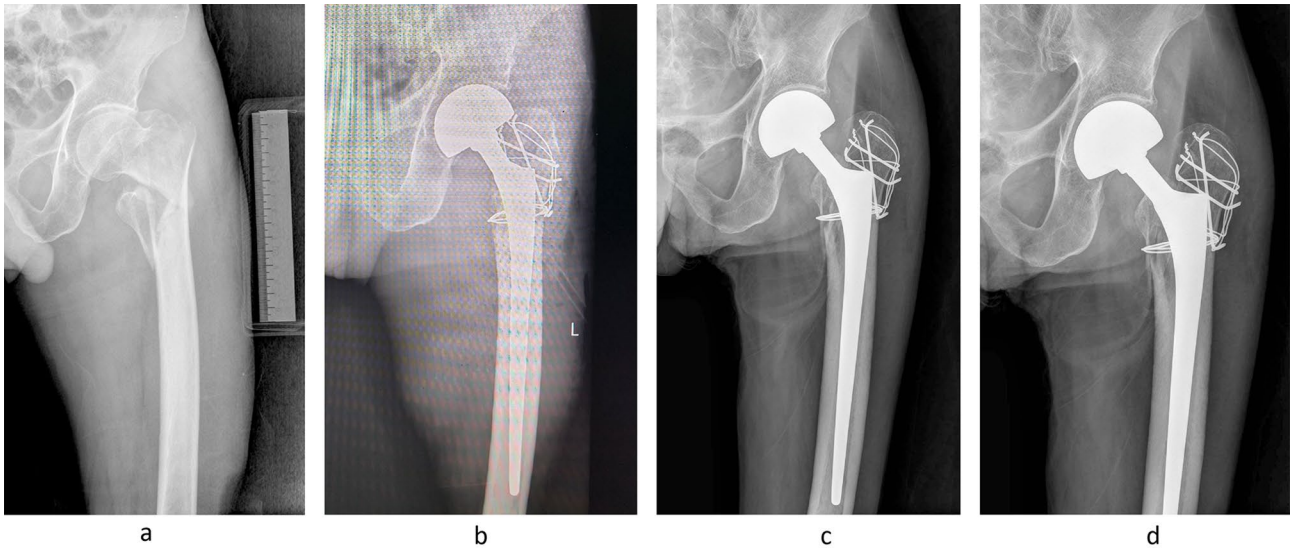

Fig. 1 An 80-year-old man with right hip pain following a fall. (**a**) Radiographs showing a comminuted fracture between the left femoral intertrochanteric region. (**b**) He underwent long-stemmed bipolar cemented hemiarthroplasty (LCHA). (**c**) First-month postoperative X-ray. (**d**) Follow-up X-rays taken in the first year after surgery

in age and ASA classification. Furthermore, a propensity score matching approach was utilized to ensure a balanced dataset, including age and ASA classification covariates. Ultimately, 77 matches were generated in both the IF and LCHA groups. In this study, we used univariate and multivariate generalized estimating equation (GEE) analyses to examine the impact of various surgical interventions on postoperative ambulatory ability. The proportional hazards assumption in the Cox regression analysis for each covariate was assessed via the Schoenfeld residual test. Time-dependent covariates were analyzed using time-dependent Cox regression analysis. Further stratified analysis was conducted for those aged 75–85 years and those aged ≥ 85 years. Cox regression analysis was used to evaluate the discrepancies in the impact of the two surgical procedures on mortality across different age groups. Our analysis specifically focused on assessing the associations between the two distinct surgical procedures and the outcomes of interest. In the sensitivity analysis, we investigated the associations between the alanine aminotransferase (ALT), aspartate aminotransferase (AST), and De Ritis ratios and postoperative mortality, with the ALT, AST, and De Ritis ratios as categorical variables, via unadjusted and multivariable-adjusted models [16]. Statistical analyses were conducted via SPSS (version 27.0) and R 4.1 software. Statistical significance was set to $p < 0.05$.

Results

Finally, the analysis included 121 patients in the LCHA group and 120 patients in the IF group (see additional file Table S1). The median follow-up durations were 22.0 months (interquartile range [IQR] 14.0–29.0 months) and 24.0 months (IQR 12.0–36.0) for the IF and LCHA groups, respectively (Table 3).

Table S1 shows the original dataset and the propensity score matching dataset. No statistically significant differences ($p > 0.05$) were found in the initial baseline characteristics between the matched pairs of patients in the IF and LCHA groups (see additional file Table S1). Similarly, no statistically significant differences were observed in the clinical outcomes of surgical treatment between the IF and LCHA groups ($p > 0.05$) (Table 3). In the IF group, one patient had a peri-implant fracture combined with a cut-out of the head screw, and another had a cut-through of the head screw. Another patient had only a peri-implant fracture. In the LCHA group, one patient experienced postoperative dislocation of the femoral head due to a fall, and another patient sustained a fracture of the distal femur of the prosthesis. In the IF group, one patient experienced a Z effect. He had a cut-through of the length of the tension screw, and the compression screw was withdrawn (Fig. 2), whereas in the LCHA group, three patients experienced severe intraoperative bone cement implantation syndrome (defined as the occurrence of cardiopulmonary resuscitation necessitated by cardiovascular collapse). Postoperatively, two of these patients necessitated intensive care unit (ICU) admission, and two were alive at 2 and 3 years of follow-up. However, one patient died within 1 month of surgery. The rate of implant-related local complications was not significantly different between the two groups ($p = 0.403$). Ten and nine patients in the LCHA and IF groups, respectively, were readmitted due to ipsilateral femur fractures or fractures elsewhere caused by falls, with no significant difference in the rate of refracture hospitalization between the two groups ($p = 0.826$). Furthermore, one and five patients in the IF and LCHA groups, respectively, were admitted to the ICU postoperatively, with no significant difference in the rate of postoperative admission to the ICU between the two groups

Table 3 Transfusion, blood loss, and postoperative outcomes in the two groups

Outcomes	IF group ($n = 120$)	LCHA group ($n = 121$)	*p.overall*
Number transfused intraop(n, transfusion rate, %)	55 (45.8%)	63 (52.1%)	0.333[a]
Transfusion rate 1 d postop, n (%)	15 (12.5%)	10 (8.3%)	0.281[a]
Value transfused RBC units (for those transfused), median (IQR)	1.5 (0, 2)	1.5 (0, 2)	0.822[b]
Vloss total2d, mL, median (IQR)	837.1(347.3, 1383.4)	727.8 (334.7, 1075.2)	0.138[b]
Hbloss total2d, g/dL, median (IQR)	88.8 (37.2, 123.7)	73.6 (37.0, 104.7)	0.144[b]
Severe cement reaction, n (%)	0 (0%)	3 (2.5%)	0.083[a]
Implant local complicationsc, n (%)	4 (3.3%)	2 (1.7%)	0.403[a]
Refracture hospitalization rates, n (%)	9 (7.5%)	10 (8.3%)	0.826[a]
Postoperative ICU admission rate, n (%)	1 (0.8%)	5 (4.1%)	0.100[a]
Incidence of deep vein thrombosis in popliteal vein and aboved, n (%)	1 (0.8%)	1(0.8%)	0.995[a]
Follow-up period, m, median (IQR)	20.0 (14.0, 29.0)	24.0 (12.0, 36.0)	0.255[b]

Notes: Frequencies (%) or medians (IQRs); [a] chi-square test; [b] Mann–Whitney U test; cimplant local complications (cut-out, cut-through, joint dislocation, and peri-implant fractures); dincidence of deep vein thrombosis in the popliteal veins and above in both lower limbs

Abbreviations: Vloss total 2 d: mean total blood loss 2 days after surgery; Hbloss total 2 d: mean total Hb loss 2 days after surgery; ICU, intensive care unit; IQR, interquartile range; RBC, red blood cell; postop, postoperative

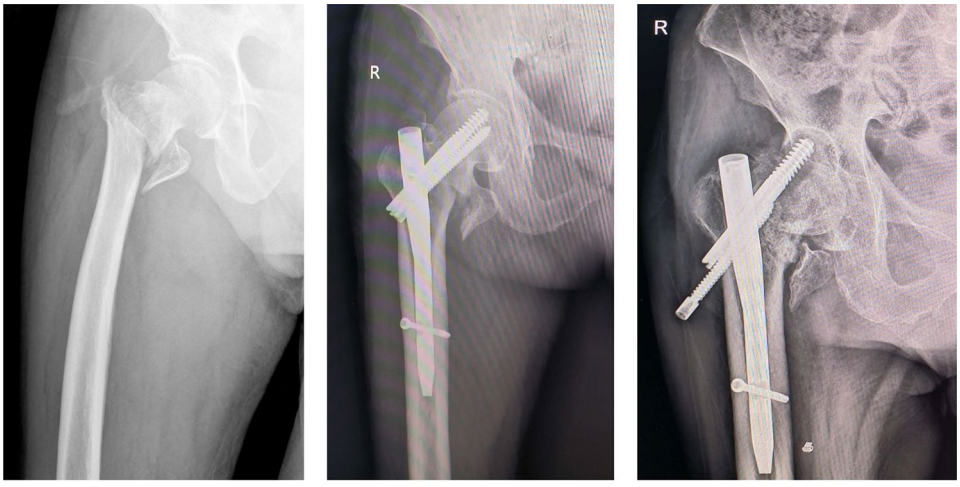

Fig. 2 At 31 months postsurgery, a 96-year-old male patient presented at the hospital seeking evaluation for persistent right hip pain. (**a**) Preoperative X-ray revealed a comminuted fracture involving the right femoral trochanter. (**b**) First-month postoperative X-ray. (**c**) Follow-up at the 31st month after surgery; the patient had a cut-through of the length tension screw, and the compression screw was withdrawn

Table 4 The association between surgical approach and postoperative changes in ambulatory ability

Group	Uni-variate analysis		Multivariate analysis	
	OR (95%CI)	Praw	OR (95%CI)	Padj
IF	Reference		Reference	
LCHA	0.822 (0.591, 1.144)	0.245[a]	0.795 (0.573, 1.103)	0.169[a]

Note: OR, odds ratio; 95% CI, 95% confidence interval; univariate and multivariate generalized estimating equation analysis (based on propensity score matching data, 77 matches)

Table 5 Comparison of mortality rate between two groups of patients at different time periods

Postoperative follow-up timepoint	IF group N1 (N2) (Mortality)	LCHA group N1 (N2) (Mortality)	*p.* overall
The 3rd month	4(120) (3.3%)	6(121) (5.0%)	0.518[a]
The 6th month	8(120) (6.7%)	9(116) (7.8%)	0.746 [a]
The 9th month	8(118) (6.8%)	11(112) (9.8%)	0.402[a]
One-year	10(117) (8.5%)	15(111) (13.5%)	0.23[a]
Two- year	13(66) (19.7%)	21(86) (24.4%)	0.489[a]
Three -year	11(31) (35.5%)	19(58) (32.8%)	0.796[a]

Note: N1, number of dead patients; N2, total number of patients; chi-square test

($p = 0.100$). One patient in the LCHA group developed partial thrombosis of the common femoral vein in the deep femoral vein after surgery, whereas another patient in the IF group developed partial thrombosis of the lower femoral vein. There was no significant difference in the incidence of deep vein thrombosis in the popliteal vein or above between the two groups. ($p = 0.995$) (Table 3).

After the datasets were matched via GEE analysis, the LCHA group had a 0.822-fold greater risk of reduced ambulatory ability than the IF group did in the univariate analysis (odds ratio [OR] = 0.822, 95% confidence interval [CI] [0.59, 1.14], $p = 0.245$). In the multivariate analysis adjusted for age and sex, the risk of reduced ambulation was 0.795 times greater in the LCHA group than in the IF group (OR = 0.795, 95% CI [0.57, 1.10], $p = 0.169$). Overall, Table 4 reveals no significant difference ($p > 0.05$) in ambulatory ability between the LCHA and IF groups.

There was no statistically significant difference in mortality rates between the two groups of patients at 3 months, 6 months, 9 months, 1 year, 2 years, or 3 years postoperatively ($p > 0.05$, Table 5). The Kaplan–Meier survival analysis, considering death as the endpoint, indicated no statistically significant difference in overall survival between the two patient groups following surgery ($p = 0.15$, Fig. 3). According to the propensity score-matched dataset, the risk of postoperative all-cause death was 1.39 times greater in the LCHA group than in the IF group according to the univariate analysis (OR = 1.39, 95% CI [0.81, 2.39], $p = 0.949$). In the multivariate analysis, after we corrected for sex and age, the risk of postoperative all-cause death was 1.35 times greater in the LCHA group than in the IF group (OR = 1.35, 95% CI [0.78, 2.35], $p = 0.740$). However, no significant difference was observed between the two groups in terms of the risk of postoperative all-cause mortality ($p > 0.05$, Table 6).

Additionally, Cox regression multivariate analysis revealed no significant difference in all-cause mortality rates between the two surgical procedures in the group of older patients aged 75–84 years (OR = 0.76, 95% CI [0.37, 1.55], $p = 0.446$), whereas a significant difference was observed in those aged ≥ 85 years ($p < 0.05$, Table 8). In individuals aged ≥ 85 years, the risk of postoperative all-cause death was 3.01 times greater in the LCHA group than in the IF group according to the Cox regression multivariate analysis (OR = 3.01, 95% CI [1, 9.02], $p = 0.049$; Table 7).

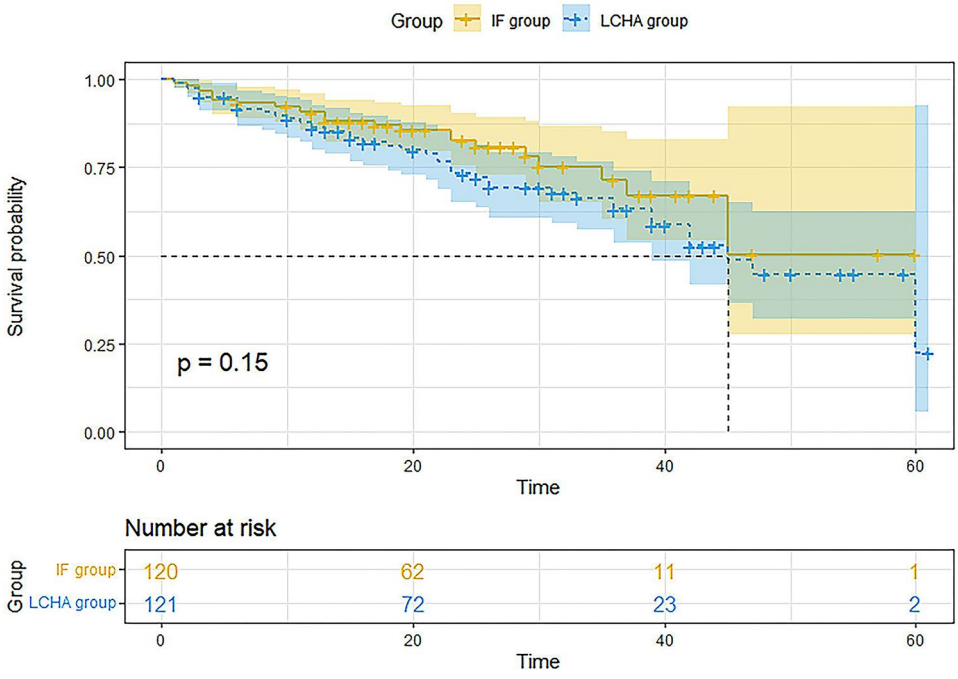

Fig. 3 Kaplan–Meier survival curves of the two groups, with death as the endpoint. Overall postoperative survival analysis of patients in both groups

Table 6 The association between two surgical approaches and postoperative mortality

Group	Uni-variate analysis[a]		Multivariate analysis[a]	
	OR (95%CI)	Praw	OR (95%CI)	Padj
IF	Reference		Reference	
LCHA	1.39 (0.81, 2.39)	0.949[a]	1.35 (0.78, 2.35)	0.740[a]

Note: OR, odds ratio; 95% CI, 95% confidence interval; univariate and multivariate generalized estimating equation analyses

Table 7 Relationship between the two surgical approaches and postoperative mortality after stratification by age

Group	Uni-variate analysis[a]		Multivariate analysis[a]	
	OR (95%CI)	Praw	OR (95%CI)	Padj
75 ≤ Age < 85				
IF	Reference		Reference	
LCHA	0.85 (0.42, 1.71)	0.640	0.76 (0.37, 1.55)	0.446
Age ≥ 85				
IF	Reference		Reference	
LCHA	2.91 (0.99, 8.6)	0.053	3.01 (1, 9.02)	0.049

Note: OR, odds ratio; 95% CI, 95% confidence interval; [a]Cox regression analysis

We analyzed all the baseline clinical factors in Table S1, as well as preoperative hemoglobin, hematocrit, platelet, and total blood transfusion data, during the perioperative period to explore their potential risk factors for postoperative all-cause mortality. Sex, age, number of comorbidities, and AST levels were significantly associated with postoperative mortality. Notably, men were at a greater risk of postoperative death than women were (OR = 1.82, 95% CI [1.10, 3.01], $p = 0.018$), and age was positively associated with postoperative mortality (hazard ratio [HR] = 1.09, 95% CI [1.04, 1.14], $p = 0.000$). AST levels were negatively associated with postoperative mortality (HR = 0.95, 95% CI [0.92, 0.99], $p = 0.019$). Individuals with one, two, or three comorbidities had a greater risk of postoperative death than those without comorbidities did (HR = 9.76, 95% CI [1.31, 72.92], $p = 0.026$; HR = 9.16, 95% CI [1.23, 68.5], $p = 0.031$; HR = 11.87, 95% CI [1.6, 88.08], $p = 0.016$; Table 8).

Table 9 shows that in the univariate model, the risk of postoperative death was 0.35 times greater in individuals with high AST levels than in those with low AST levels (HR = 0.35, 95% CI (0.16, 0.78), $p = 0.010$). Those with a median De Ritis ratio had a lower risk of postoperative death than those with a low ratio did (HR = 0.54, 95% CI [0.31, 0.95], $p = 0.033$). According to the multivariate model, individuals with moderate and high AST levels were at 0.50 times and 0.30 times greater risk of postoperative death than those with low AST levels were (HR = 0.50, 95% [0.28, 0.90], $p = 0.020$ and HR = 0.30, 95% CI [0.13, 0.68], $p = 0.004$, respectively). Those with a median De Ritis ratio were at a 0.45 times greater risk of postoperative death than those with a low ratio (HR = 0.45, 95% CI [0.25, 0.81], $p = 0.008$).

Discussion

As medical technology continues to advance, an expanding body of research has been devoted to investigating the optimal surgical treatment plans for IFF [17]. Recent evidence suggests that two-screw proximal femoral intramedullary nailing may result in a lower incidence of

Table 8 Univariate and multivariate analysis of factors associated with mortality after surgery

	Uni-variate analysis[a]		Multivariate analysis[a]	
	OR (95%CI)	Praw	OR (95%CI)	Padj
Characteristics				
Sex				
Female	Reference		Reference	
Male	1.67 (1.02, 2.75)	0.039	1.816 (1.10,3.01)	0.018
Age	1.08 (1.03, 1.13)	0.001	1.09 (1.04, 1.14)	0.000
Numbers of comorbidities				
0	Reference		Reference	
1	10.28 (1.38, 76.54)	0.023	9.76 (1.31, 72.92)	0.026
2	10.10 (1.35, 75.27)	0.024	9.16 (1.23, 68.50)	0.031
>=3	14.22 (1.92,105.21)	0.009	11.87 (1.6, 88.08)	0.016
AST	0.96 (0.92, 0.99)	0.018	0.95 (0.92, 0.99)	0.019
Total blood transfusion	2.26 (1.31, 3.90)	0.003	2.12 (1.21, 3.72)	0.009

Note: OR, odds ratio; 95% CI, 95% confidence interval; [a]Univariate and multivariate analysis (based on the original dataset, showing only statistically significant factors)

implant-related complications than single-screw proximal femoral intramedullary nailing for IFF fixation [2–3, 18]. However, the use of intramedullary nail fixation in adults aged > 75 years may result in a greater incidence of complications, such as nonunion, internal fixation failure, lag screw cut-out, and medial migration of shortened femoral neck screws [19–22]. In our opinion, for patients younger than 75 years, intramedullary nail fixation represents the primary treatment approach for IFF. Therefore, including this age group in a comparative study of hemiarthroplasty and intramedullary nailing is inappropriate. Recent studies have demonstrated the effectiveness of initial LCHA for IFF in facilitating early weight bearing, reducing complications associated with immobility, improving patients' quality of life, and alleviating the burden on family caregivers [7]. Cobden et al. reported that cemented hemiarthroplasty was associated with satisfactory functional outcomes and a low reoperation rate in patients with IFF [5]. LCHA is a treatment option available to patients; however, research comparing the clinical outcomes of IF and LCHA in adults aged 75 years is limited, particularly without conducting a risk factor analysis for postoperative death.

Recent studies have suggested that LCHA replacements have fewer postoperative complications than intramedullary nailing for treating IFF in older adults [5, 8, 23]. However, Lu et al. found no significant difference in postoperative complications between the two groups of nonagenarians [24]. Notably, most of these studies did not restrict the included patients' age to 75 years, nor did they report severe cement reactions intraoperatively. In our study, no significant difference was observed between the two surgical approaches regarding postoperative local implant complications, refracture hospitalization rates, or postoperative ICU admission rates. Additionally, we observed a rare Z effect of IF in a 96-year-old patient, indicating that this method may have a Z effect in older patients with fixation and reduction quality and severe osteoporosis. This finding emphasizes the importance of patient age and bone health when selecting a surgical approach to treat IFF. In the LCHA group, the incidence of severe cement implantation syndrome was 2.5%, similar to the 1.7% incidence of severe cement implantation syndrome reported in Flaviu's study and Olsen et al.'s study [25].

Kumar et al. reported that hemiarthroplasty resulted in greater blood loss than internal fixation [26]. In

Table 9 Sensitivity analysis on ALT, AST, and de Ritis ratio as categorical variables and postoperative mortality

Categorical variables[c]	Death	Patients	Unadjusted		Multivariable adjusted	
	n	*N*	HR (95% CI)	*P*	HR (95% CI)	*p*
ALT						
Low (≤ 9 IU/L)	16	56	Reference		Reference	
Middle (9-19IU/L)	39	134	0.82 (0.46, 1.49)	0.517[a]	0.78 (0.43, 1.42)	0.415[b]
High (≥ 19IU/L)	11	51	0.54 (0.25, 1.18)	0.123[a]	0.50 (0.23, 1.11)	0.090[b]
AST						
Low (≤ 14 IU/L)	19	51	Reference		Reference	
Middle (14–24 IU/L)	38	140	0.63 (0.37, 1.10)	0.105[a]	0.50 (0.28, 0.90)	0.020[b]
High (≥ 24 IU/L)	9	50	0.35 (0.16, 0.78)	0.010[a]	0.30 (0.13, 0.68)	0.004[b]
De Ritis ratio						
Low (≤ 1.08 IU/L)	19	46	Reference		Reference	
Middle (1.08-2.00IU/L)	34	142	0.54 (0.31, 0.95)	0.033[a]	0.45 (0.25, 0.81)	0.008[b]
High (≥ 2.00IU/L)	13	53	0.73 (0.36, 1.49)	0.394[a]	0.61 (0.29, 1.28)	0.192[b]

Notes: [a] unadjusted analysis; [b] multivariable adjusted analysis; categorical variables were categorized into low (≤20th percentile), medium (20th–80th percentile), and high (≥ 80th percentile) trichotomies on the basis of the 20th and 80th percentiles[15]

Abbreviations: HR, hazard ratio; CI, confidence interval; AST, aspartate aminotransferase; ALT, alanine aminotransferase

contrast to previous studies, the current widespread use of tranexamic acid for hemostasis in the perioperative period of orthopedic surgery has led to reduced blood loss. Our study revealed no significant differences in total blood loss, hemoglobin fluctuations, allogeneic transfusions, or transfusion rates between the two groups of patients from the preoperative period to 6 am on the morning of postoperative day 2.

Durgut et al. compared the use of proximal femoral nail antirotation and cemented calcar-replacement hemiarthroplasty in patients aged > 75 years with IFF, and no significant difference was observed in terms of postoperative length of stay, transfusion requirements, reoperation rates, or survival rates [9]. This aligns with our study, and we conducted a propensity score matching cohort study to discuss the associations of the two surgical procedures with postoperative all-cause mortality and ambulatory ability. No significant difference was observed in postoperative ambulatory ability or all-cause mortality between the two groups in our study. In addition, the indicators of the clinical baseline characteristics included in our study were more comprehensive. When exploring factors that may influence postoperative mortality, we found a significant association between sex, age, number of comorbidities, total number of perioperative blood transfusions, AST levels, and postoperative all-cause mortality. Notably, male patients presented a greater risk of postoperative death, and their risk of postoperative death increased with age. The risk of death increased proportionately for 1–2 or 3 or more comorbidities, and the higher the total number of perioperative allogeneic blood transfusions was, the greater the risk of postoperative death. In older adults aged 75–84 years, no statistically significant differences were found in all-cause mortality between the two surgical approaches. However, in patients aged ≥ 85 years, the IF group demonstrated a lower rate of all-cause mortality than did the LCHA group. These findings suggest that both surgical approaches may be viable in the 75–84 years group, but preference should be given to IF in patients aged 85 years or older. As age increases, individuals become less capable of withstanding intraoperative trauma and complications, and the LCHA group has been observed to experience more trauma intraoperatively than the IF group. Consequently, it is postulated that this may contribute to the higher mortality rate observed in patients with LCHA aged 85 years or older. AST levels are negatively associated with the risk of postoperative mortality. Surprisingly, we first reported this result in a postoperative intertrochanteric fracture in a patient aged 75 years. Sensitivity stratification analysis revealed that individuals with low AST levels had a greater risk of postoperative death than those with moderate-to-high AST levels did. Individuals with a low De Ritis ratio had a greater risk of postoperative death than those with an intermediate ratio did. Our analysis suggested that the reduced survival rate in elderly individuals with low AST levels and low De Ritis ratios may be related to aging and fragility of organs, such as the liver and heart. In conclusion, these exploratory findings await further study and will be informative for assessing the prognosis of elderly patients with IFF after surgery.

Finally, no significant difference was observed between LCHA and IF in terms of total blood loss intraoperatively and at 2 days postoperatively, transfusion rates and local complications of the implant postoperatively, refracture hospitalization rates, postoperative ICU admission rates, postoperative ambulatory ability, overall survival, or mortality. Early ambulation after cemented hemiarthroplasty prevents complications from prolonged bed rest. Nherera et al. reported that cost-effectiveness should be considered when selecting an internal fixation method for IFF [1]. We believe that patients discharged from bed rest with weight bearing after IF fixation, rather than LCHA, will incur higher costs for rehabilitation and care after discharge. Therefore, LCHA is considered more beneficial from a postoperative cost-effective perspective. In particular, patients who are unable to stay in bed for long periods and are at risk of severe deterioration if they do not quickly regain motor function may benefit from hemiarthroplasty.

This study has several limitations. First, the sample size should be increased in future studies, especially when exploring the prediction of postoperative mortality using factors such as preoperative AST. Second, although patients voluntarily choose the procedure to undergo preoperatively, the surgeon's treatment preference may influence patient choice. Third, we only assessed Koval grades when assessing functional outcomes and did not compare other hip scores because some patients were unable to visit the hospital for follow-up due to the coronavirus disease pandemic or other reasons. The follow-up of Koval grades by telephone was simpler but not more detailed than the in-person follow-up. Future research should encompass longer follow-up periods for a more comprehensive understanding.

Conclusions

To our knowledge, few studies have compared the effects of age restrictions on the choice of IF or LCHA treatment for elderly patients with IFF aged 75 years or older. The current study attempted to fill this gap in the literature. In elderly patients aged 75–84 years with intertrochanteric femur fractures, both internal fixation (IF) and long-stemmed cemented hemiarthroplasty (LCHA) are viable treatment options. However, for patients aged 85 years and older, IF is associated with a relatively lower postoperative all-cause mortality rate and should be prioritized

as a treatment modality. Additionally, preoperative AST levels may serve as a valuable predictor of postoperative all-cause mortality in elderly patients undergoing surgery for intertrochanteric femur fractures.

Abbreviations

Cr	Blood creatinine
BUN	Blood urea nitrogen
PT	Prothrombin time
FIB	Fibrinogen
APTT	Activated partial thromboplastin time
TT	Plasma thrombin time
ALT	Alanine aminotransferase
AST	Aspartate aminotransferase
ASA	American Society of Anesthesiologists
GEE	Generalized estimating equation
HR	Hazard ratio
ICU	Intensive care unit
IF	Internal fixation
IFF	Intertrochanteric femoral fractures
IQR	Interquartile range
LCHA	Long-stemmed cemented bipolar hemiarthroplasty
NT-proBNP	N-terminal pro-B type natriuretic peptide
OR	Odds ratio

Supplementary Information

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Supplementary Material 1: Table S1. Basic characteristics and preoperative, operative duration, and hospital stay data of the two groups.

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Author contributions

YD and ZMT: study design, case data collection and organization, analysis and interpretation, and manuscript writing. XPZ and BS: patient follow-up, acquisition of data, and preparation of the manuscript; YD and GHL: evaluation of the fracture (OTA/AO-2018) classification, data acquisition, and manuscript preparation. The final version of the manuscript has been reviewed and approved by all authors.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

All methods employed in this study were conducted in strict accordance with the relevant guidelines and regulations. Ethical approval for this research was obtained from the Institutional Ethics Review Board of the Loudi Central Hospital (Approval Number: [IEC-AF/17 – 1.0.]). Written informed consent was obtained from all participants prior to their participation in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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