Impact of Diabetes Mellitus on Early Postoperative Outcomes After Hip Fracture Surgery in Geriatric Patients: A Retrospective, Propensity Score Matching Study

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Abstract

Background The impact of diabetes mellitus (DM) on hip fracture (HF) is still controversial. The primary aim of this study was to examine the influence of DM on perioperative transfusion the secondary aims were to evaluate 1-year mortality, length of stay and total charges in individuals with hip fracture.

Methods: All patients with initial HF aged 60 years or older admitted to our hospital from January 2014 to January 2018 were eligible for this study. After excluding some patients who did not meet the experimental requirements, 326 HF patients aged 60 years and above were admitted to the study institution, and were divided into DM group (n=71) and non-diabetes mellitus (non-DM) group (n=255). Sex, age, American Society of Anesthesiologists (ASA) classification, anesthesia type and surgery type were matched in the two groups (DM group vs. non-DM group) using propensity score matching (PSM) without any statistical differences. Then perioperative transfusion length of stay direct total charges and 1-year mortality in individuals with HF were compared between two groups.

Results: Following PSM, 62 patients in the DM group and 62 patients in the non-DM group were included in the study. Twenty-eight patients had received blood transfusion during the perioperative period, the difference in blood transfusion rate between two groups was statistically significant ($p=0.032$). There were no statistical differences in 1-year mortality, length of stay and direct hospital costs between two groups.

Conclusions: This study showed that DM patients with hip fractures have a higher probability of receiving transfusions compared to patients without DM. Higher blood transfusion rates may be associated with lower hemoglobin and hematocrit levels at admission. However, there was no significant increase in 1-year mortality, length of hospital stay, and direct hospital costs after hip fracture surgery due to diabetes.

Background

Hip fracture is one of the most serious health problems affecting the quality of life of the elderly and the second leading cause of hospitalization in the elderly [1]. Hip fracture often results in poor quality of life, limb dysfunction and high mortality [2]. It was reported that the postoperative mortality of elderly patients with hip fracture is about 15%-20% [3–5]. Surgical treatment is preferred for hip fractures; however, the surgical outcome depends on factors such as age, comorbidity, and patient's prior activity [6].

Diabetes mellitus (DM) is a common and serious chronic disease, which often causes many health problems such as diabetes-related cardiovascular diseases, diabetic nephropathy and diabetic peripheral neuropathy [7]. A large number of studies demonstrated that DM increases the incidence of hip fractures [8, 9], but the influence of diabetes on early postoperative outcomes of hip fractures remains controversial. In particular, there were relatively few studies on the influence of DM on perioperative blood transfusion rate for hip fractures. It is unknown whether DM increases the perioperative blood transfusion rate for hip fractures or not.

To address these concerns, we designed a propensity score matching (PSM) cohort study of hip fractures treated surgically in our hospital. Compared with previous observational studies, the method of PSM can effectively reduce the influence of data bias and confounding factors. Our primary objective was to determine whether DM affects perioperative blood transfusion rates for hip fractures. Secondary outcomes included length of stay, cost of stay, and 1-year mortality.

Materials And Methods

Study design

This retrospective, PSM cohort study was conducted in the department of orthopedics in author's hospital. This retrospective study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Human Investigation Committee (IRB) of author's Hospital approved this study.

Patients and data sources

All patients over 60 years old with hip fracture admitted to our hospital from January 2014 to January 2018 were eligible for inclusion in this study. Exclusion criteria included periprosthetic fracture, multiple injuries or compound injuries, non-surgical treatment, and follow-up time less than 1 year. Patients with type 1 DM, type 2 DM, other specified DM and unspecified DM were classified as DM for the purposes of this study. During the study period, 458 hip fracture patients were admitted to the study institution. Among them, 107 patients were excluded because of refusal of surgical treatment, 8 patients were excluded because of multiple fractures in other sites, 4 patients were excluded because of craniocerebral injury, and 13 patients were excluded because of loss of follow-up. Finally, 326 patients were included in the study, including 71 patients with DM and 255 patients without DM. Baseline data, perioperative blood transfusion rates, length of stay, and direct hospitalization costs were obtained from the authors' hospital information management system, and 1-year mortality was obtained through telephone interviews. Sex, age, American Society of Anesthesiologists (ASA) classification [10], anesthesia type and surgery type were matched in two groups (DM group vs. non-DM group) using PSM without any statistical differences (See Fig. 1).

The American Society of Anesthesiologists (ASA) classification is convenient for all surgical patients and has been shown to be useful in assessing the patient's health status and anesthesia risk. Anesthesia type included intraspinal anesthesia and general anesthesia with endotracheal intubation. Anesthesia was determined by the anesthesiologist. The surgical methods included hemi-hip arthroplasty, total hip arthroplasty, cannulated screw internal fixation and femoral intramedullary nail fixation, which was decided by the surgeon according to the patient's fracture type and physical condition. All cannulated screw internal fixation and intramedullary nail fixation were minimally invasive procedures. All total hip arthroplasty and hemi-hip arthroplasty were open procedures.

Statistical analysis

Logistic regression was used to generate propensity scores for patients in the DM and non-DM cohorts. Patients were matched at a ratio of 1:1 using the following covariates: age, sex, ASA classification, anesthesia type, and surgery type. Propensity was performed using the “MatchIt” package provided with R software. The algorithm used established matches based on the logit of the propensity score with a 0.10 SD caliper width. Variables with large standardized differences were included in the model priori. Balance between cohorts was checked at each iteration using standardized differences, and unbalanced variables were included in the next model. These steps were repeated iteratively until all baseline variables were balanced between two cohorts. Matching was performed without arthroplasty (ie, subjects were available for matching only once). At the end of this iterative process, unique pairs of subjects with very similar propensity scores were identified in a ‘greedy’ manner. The matching process was completed by SPSS V2.5. We believe that in the case of 1:1 matching, the accuracy of matching will be better and the baseline data between two groups will be more consistent. At the same time, we found that the number of cases in the DM group would decrease after 1:2 matching, so we adopted 1:1 matching method. After propensity score matching, there were 124 cases, including 62 DMs and 62 no-DMs.

Using Chi-squared tests for categorical variables and Student’s *t*-tests for continuous variables, patient demographic characteristics and postoperative outcomes were assessed. We observed the obtained data, and all the data were approximately normally distributed. All of the statistical tests were two-tailed, and statistical significance was defined as $p < 0.05$. All of the statistical calculations were performed via SPSS Statistics V.25 (IBM Corporation, NY, USA).

Results

We identified 326 patients who underwent hip fracture surgery in the study period, of which 21.8% ($n = 71$) with DM, 78.2% ($n = 255$) without DM, the mean follow-up was 28.9 months. The unmatched cohorts differed in a number of baseline characteristics (See Table 1). The majority of DM patients were female (85.9%, $n = 61$), with a higher ASA typing and a higher incidence of regional anesthesia (43.7% vs 30.2%).

Of those patients in the DM group, 87.3% ($n = 62$) were matched to similar patients who without DM (See Table 2).

There was no significant difference in preoperative waiting time ($p = 0.845$) and baseline albumin levels ($p = 0.449$) at admission between the DM group and the non-DM group. However, patients in the diabetes group were admitted with lower baseline hemoglobin levels and lower baseline erythropoiesis compared with those in the non-diabetic group (See Table 3).

Twenty-eight patients had received blood transfusion during the perioperative period, among which 19 (30.6%) were diabetic patients, 9 (14.5%) were non-diabetic patients, 17 patients (60.7%) who underwent total hip arthroplasty, 7 patients (25%) underwent femoral intramedullary nail fixation, and 4 patients (14.3%) underwent hemi-hip arthroplasty. The difference in blood transfusion rate between two groups

was statistically significant ($p = 0.032$). Fourteen patients died within 1 year after surgery, including 8 in the DM group (12.9%) and 6 in the non-DM group (9.7%). There was no statistical difference in 1-year mortality between two groups ($p = 0.57$). The average length of stay of diabetic patients (19.6 ± 8.4 days) was 0.3 days longer than that of non-diabetic patients (19.3 ± 7.8 days), but there was no statistical difference between two groups ($p = 0.857$). The average cost of hospitalization in the diabetic group ($41,729.2 \pm 14,103.5$ yuan) was 801.3 yuan more than that in the non-diabetic group ($42,530.5 \pm 11389.4$ yuan), but there was no statistical difference between two groups ($p = 0.449$)(See Table 4).

Table 1
Baseline characteristics of all patients before propensity score matching

	Diabetes mellitus	Non - diabetes mellitus	Total/ Average	p-value
Sex, n (%)				0.01 †
Male	10(14.1%)	88(34.5%)	98(30.1%)	
Female	61(85.9%)	167(65.5%)	228(69.9%)	
Mean age, yrs (range; SD)	77.6 (61 to 93; 9.0)	78.1 (60 to 99; 8.5)	77.9 (60 to 99; 8.6)	0.674 ‡
Follow-up, mths (range; SD)	28.4 (13 to 45; 7.1)	29.3 (14 to 44; 8.1)	28.9 (13 to 45; 7.6)	N/A
ASA classification				0.046 †
1	16(23.9%)	50(19.6%)	66(20.2%)	
2	25(33.8%)	127(49.8%)	152(46.7%)	
3	23(32.4%)	68(26.7%)	91(27.9%)	
4	7(9.9%)	10(3.9%)	17(5.2%)	
Anesthesia type				0.033 †
Intraspinal anesthesia	31(43.7%)	77(30.2%)	108(33.1%)	
General anesthesia	40(56.3%)	178(69.8%)	218(66.9%)	
Surgery type				0.861 †
Hemi-hip arthroplasty	20(28.2%)	73(28.6%)	93(28.5%)	
Total hip arthroplasty	13(18.3%)	38(14.9%)	51(15.6%)	
Cannulated screw internal fixation	7(9.9%)	32(12.5%)	39(12.0%)	
Femoral intramedullary nail fixation	31(43.7%)	112(43.9%)	143(43.9%)	
SA classification, American Society of Anesthesiologists classification.				
†, Chi-squared tests				
‡, Student's <i>t</i> -tests				
N/A, not applicable				

Table 2
Baseline characteristics of all patients after propensity score matching

	Diabetes mellitus	Non - diabetes mellitus	Total/ Average	p-value
Sex, n (%)				0.248 [†]
Male	9(14.5%)	14(22.6%)	23(18.5%)	
Female	53(85.5%)	48(77.4%)	101(81.5%)	
Mean age, yrs (range; SD)	76.5 (62 to 92; 7.5)	78.9 (61 to 99; 9.5)	77.7 (61 to 99; 8.6)	0.124 [‡]
Follow-up, mths (range; SD)	28.6 (14 to 45; 7.9)	28.3 (13 to 44; 8.7)	28.5 (13 to 45; 8.3)	N/A
ASA classification				0.545 [†]
1	13(21.0%)	12(19.4%)	25(20.1%)	
2	22(35.5%)	19(30.6%)	41(33.1%)	
3	20(32.3%)	27(43.5%)	47(37.9%)	
4	7(11.3%)	4(6.5%)	11(8.9%)	
Anesthesia type				0.457 [†]
Intraspinal anesthesia	25(40.3%)	21(33.9%)	46(37.1%)	
General anesthesia	37(59.7%)	41(66.1%)	78(62.9%)	
Surgery type				0.616 [†]
Hemi-hip arthroplasty	17(27.4%)	23(37.1%)	40(32.3%)	
Total hip arthroplasty	12(19.4%)	8(12.9%)	20(16.1%)	
Cannulated screw internal fixation	7(11.3%)	6(9.7%)	13(10.5%)	

ASA classification, American Society of Anesthesiologists classification.

†, Chi-squared test

‡, Student's *t*-test

N/A, not applicable

	Diabetes mellitus	Non - diabetes mellitus	Total/ Average	p-value
Femoral intramedullary nail fixation	26(41.9%)	25(40.3%)	51(41.1%)	
ASA classification, American Society of Anesthesiologists classification.				
†, Chi-squared test				
‡, Student's <i>t</i> -test				
N/A, not applicable				

Table 3

Preoperative waiting time and hematological baseline indicators of diabetic and non-diabetic patients

	Diabetes mellitus	Non - diabetes mellitus	p-value
Preoperative waiting time, d (range; SD)	6.5(2.2 to 21.5; 2.3)	6.4 (1.5 to 23; 4.9)	0.845 †
Baseline hemoglobin, g/L (range; SD)	98.6 (62 to 126; 17.6)	117.2 (62 to 150; 18.7)	0.000 †
Baseline hematocrit, L/L (range; SD)	32.6 (24 to 43; 4.3)	35.3 (25 to 45; 5.5)	0.003 †
Baseline albumin, g/L (range; SD)	37.2 (27.3 to 50.1; 4.1)	37.5 (26.7 to 52; 4.7)	0.449 †
†, Student's <i>t</i> -tests			

Table 4

Postoperative outcomes

	Diabetes mellitus	Non - diabetes mellitus	p-value
Blood transfusion, n (%)	19(30.6%)	9(14.5%)	0.032 †
one-year mortality, n (%)	8(12.9%)	6(9.7%)	0.57 †
Length of stay, d (range; SD)	19.6 (4 to 41; 8.4)	19.3 (8 to 48; 7.8)	0.807 ‡
Total charges, CNY (range; SD)	42530.5 (17057.9 to 78029.6; 11389.4)	41729.2 (13665.9 to 102552.0; 14103.5)	0.449 ‡
†, Chi-squared tests			
‡, Student's <i>t</i> -tests			

Discussion

The study showed that perioperative blood transfusion rates were higher in patients with hip fractures with DM than in those without DM. No notable differences in the length of stay, direct total charges, or 1-year mortality were demonstrated. This suggests that diabetes increases perioperative blood transfusion rates for hip fractures without significant increases in length of hospital stay, direct costs, and early postoperative mortality. The current study has also found that patients in the diabetic group had lower baseline hemoglobin and hematocrit levels at admission than those in the non-diabetic group, while the number of waiting days before surgery and baseline albumin levels at admission were close to those in the non-diabetic group.

In contrast to our study, Wang H et al. [11] found that the combination of diabetes did not significantly increase the perioperative transfusion demand for hip fracture. However, our findings, consistent with the findings of Chanseok R et al. and Bolognesi MP et al. [12, 13], suggesting that co-diabetes increases perioperative blood transfusion requirements for hip fractures. Mehdi U and Thomas MC [14, 15] suggest that the increased demand for blood transfusion in diabetic patients with hip fractures may be explained by evidence that diabetics are more prone to anemia. In any case, there is no clear evidence linking diabetes directly to an increased risk of perioperative blood transfusion for hip fracture, and we are more inclined to think that complications such as diabetic nephropathy and DM-related malnutrition are more likely to cause diabetes-related anemia, leading to an increase in perioperative blood transfusion demand in diabetic patients. This could explain the lower baseline hemoglobin and hematocrit levels found in our study in patients with DM who were admitted to hospital.

Notably, the study found no significant increase in the direct costs and length of hospital stay in patients with diabetes. This was completely contrary to the research results of Wang H et al. [11] and Pope D et al. [16]. The direct cost and length of stay in hospital have complicated relationship with income level, occupation type and other factors, and it is difficult to explain by single factor of DM.

In our study, the number of diabetic female patients with hip fracture (85.9%) was significantly greater than that of male patients (14.1%). These results are in line with those of previous studies [11, 17]. However, a systematic review by Janghorbani M et al. [18] found that hip fractures were more likely to occur in men with diabetes. The reason for the discrepancy may be because of different socioeconomic conditions, geographical differences, or different medical systems.

In addition, our results suggested that DM does not significantly increase the average length of stay or the cost of hospitalization in patients with hip fractures, which were consistent with Nicholas' findings [19]. This suggested that diabetes has no significant effect on length of stay, cost of stay, and 1-year mortality in patients undergoing hip fracture surgery. Although the difference in total hospital expenses was not statistically significant, the average total hospital expenses in DM group were slightly higher than those in non-DM group, possibly because the cost of blood glucose control was relatively low.

However, these results are contrary to the results of Tian Wa-O et al. [17]. So larger samples and more rigorous clinical trials are still needed to produce more reasonable results.

Although in our study, the number of deaths within 1 year in DM group (12.9%, $n = 8$) was higher than that in non-DM group (9.7%, $n = 6$), there was no statistical difference between two groups ($P = 0.57$). Two previously published studies have also reported that the presence of DM does not negatively impact survival following hip fracture surgery [20, 21]. Whether the presence of DM increases the 1-year mortality in patients with hip fractures is inconclusive and requires further studies.

The advantage of this study is that partial confounding factors were eliminated by the method of PSM, making the results more representative. At the same time, this study also has some limitations. Firstly, some hip fracture patients admitted to our hospital did not receive surgical treatment, and the basic data and outcome indicators of conservative treatment were not analyzed in this study, so it was impossible to determine whether DM affects the outcome indicators of hip fracture patients who did not receive surgical treatment. Secondly, income level, body mass index and nursing factors were also factors affecting the prognosis of hip fracture in the elderly. The influence of these factors was not analyzed in this study. In addition, homogeneity and heterogeneity tests were not performed on the included samples, but there was no significant statistical difference in demographic and clinical characteristics between the groups after PSM, which was consistent with the requirements of general retrospective study.

Conclusions

In summary, our study found that DM patients with hip fractures have a higher probability of receiving transfusions compared to patients without DM. Higher blood transfusion rates may be associated with lower hemoglobin and hematocrit levels at admission. However, there was no significant increase in 1-year mortality, length of hospital stay, and direct hospital costs after hip fracture surgery due to diabetes. The results of this study showed that diabetes did not play as large a role in postoperative complications in this group of patients as expected, which could lead to a more specific and rapid evaluation of patients with diabetes requiring hip fracture surgery. This can help clinicians improve perioperative blood management and assist patients to pass the perioperative period more safely.

Abbreviations

DM, diabetes mellitus; HF, hip fracture; PSM, propensity score matching; ASA, American Society of Anesthesiologists.

Declarations

Ethics approval: This retrospective study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki

Declaration and its later amendments or comparable ethical standards. The Human Investigation Committee (IRB) of Deyang People's Hospital approved this study.

Consent for publication: Not Applicable.

Availability of data and materials: All raw data and materials during the study are available from the first author by request. (Ruibo Li, lirb09@163.com)

Competing interest: The authors declare that they have no competing interests.

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Authors' contributions: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by RBL, YHL, SPL, XC and ZCW. The first draft of the manuscript was written by RBL. XY and QZ made meaningful correction to the structure of the article and guided the statistical methods and data processing, and all authors commented on previous versions of the manuscript. YZ participated in the design of the study and proofread the manuscript as the corresponding author. All authors have read and approved the manuscript.

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Figures

Figure 1

Flowchart and eligibility. DM, diabetes mellitus. PSM, propensity score matching. ASA, American Society of Anesthesiologists.