

Risk Factors of Falls in Hospitalized Patients with Type 2 Diabetes Mellitus: A Retrospective Study

Fei Wang

Hainan General Hospital, Hainan Affiliated Hospital of Hainan Medical University

Jingwen Yu

Hainan General Hospital, Hainan Affiliated Hospital of Hainan Medical University

Fen Wang

Hainan General Hospital, Hainan Affiliated Hospital of Hainan Medical University

Qun Ji

Hainan General Hospital, Hainan Affiliated Hospital of Hainan Medical University

Lan Gao

Hainan General Hospital, Hainan Affiliated Hospital of Hainan Medical University

Huibiao Quan

Hainan General Hospital, Hainan Affiliated Hospital of Hainan Medical University

Kaining Chen

Hainan General Hospital, Hainan Affiliated Hospital of Hainan Medical University

Wei Jin (✉ ruixuanshuyu@163.com)

Hainan General Hospital, Hainan Affiliated Hospital of Hainan Medical University

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Abstract

Background Falls of T2DM inpatients with multiple comorbidities not only lead to musculoskeletal injury but also prolonged duration of hospital stay due to delayed healing, original diseases aggravation and increased risk of nosocomial infection.

Objective To determine the risk factors of falling in T2DM patients during hospitalization.

Methods Clinical data are selected from the patients administered in the department of endocrinology in Hainan General Hospital from the year of 2015 to 2020 with 38 patients in the fall group and 38 patients in the non-fall group. Clinical features and diagnosis-treatment differences are analyzed between the two groups and the correlations of falls and variables are as well evaluated.

Results Levels of FBG, LDL-C, ALP, Morse Fall Scale (MFS), treatment of insulin or secretagogue, frequency of hypoglycemic events, diabetic peripheral neuropathy (DN), diabetic retinopathy (DR), chronic kidney disease (CKD), coexistence of cerebral infarction (CI) and osteoporosis (OP) rates in fall group were higher than those in non-fall group ($P<0.05$), the serum albumin (ALB), HDL-C and ADL scores were lower in fall group than those in non-fall group; MFS score, frequency of hypoglycemic events, DN, DR, CKD, OP, CI, FBG, LDL-C and ALP levels were positively correlated with fall ($P<0.05$); on the other hand, 25 (OH) D, serum calcium, ALB, and HDL-C levels were negatively correlated with falls ($P<0.05$); Binary logistic regression analysis revealed that low level of HDL-C and cerebral infarction were the main risk factors of falls in T2DM inpatients, and the higher the HDL-C, the lower the risk of falls ($OR=0.021, P=0.002$). Besides, the risk of falling was higher in patients with concurrent cerebral infarction ($OR=21.738, P=0.029$).

Conclusion Patients with chronic diabetic complications, cerebral infarction or osteoporosis, insulin or insulin secretagogue administration, high frequency of hypoglycemic events and low HDL-C level are at a higher risk of falling during hospitalization. Therefore, it is necessary to identify the occurrence of falling intensely, prescribe drugs with lower risk of hypoglycemia, and reinforce fall prevention education.

Background

T2DM patients are the population at risk of falling and the risk of injury will further increase. Associated risk factors of T2DM patients falls include diabetic neuropathy, polypharmacy, cognitive impairment, peripheral artery disease, vision loss, insulin treatment and hypoglycemia [1, 2, 4, 5], and the fear of falling [7–9], etc. Possible mechanism might be correlated with the balance decline and gait abnormalities [1, 9]. Hospitalized T2DM patients are usually with concurrent diseases and are more vulnerable. Moreover, environmental changes increase the risk of falling which leads to the prolongation of hospital stay and ascending risk of nosocomial infection which will eventually bring more difficulties to the treatment. However, the related analysis of falls in hospitalized T2DM patients is rarely reported. Our research retrospectively analyzed the clinical characteristics and influencing factors of falling in hospitalized T2DM patients, so as to improve the early-stage identification of high-risk groups for falls in order to reduce the occurrence of adverse events of falling during hospitalization.

Study Population And Methods

Population

Participants were recruited from the inpatients of Endocrinology department in Hainan General Hospital from January 2015 to December 2020. 38 cases who had experienced falls had been enrolled in the observation group (fall group, diabetes mellitus was diagnosed by the WHO 1999 standards). Thirty-eight patients with T2DM who were hospitalized at the same period of time without falling and whose clinical data were matched by age, gender and BMI were selected as the control group.

Clinical data: Age, gender, height, weight, waist circumference and blood pressure were collected and Body Mass Indexes (BMI) were calculated. Duration of diabetes was also collected. Chronic complications such as diabetic peripheral neuropathy (DN) was assessed by electromyography, while diabetic retinopathy (DR) by eye-ground photography, chronic kidney disease (CKD) by glomerular filtration rate (GFR), cerebral infarction (CI) by cerebral CT scan and osteoporosis (OP) by bone mass density (BMD) examination. Insulin or secretagogue administration during hospitalization, time of fall and blood glucose at the time of fall, frequency of hypoglycemic events were also gathered for analysis. Morse fall scale (MFS) was used to evaluate the risk of falling (including time of falls, diagnosis, assistant devices, intravenous fluids, gait/movement, mental state in the past 3 months. The full score is 100, 0 ~ 24 for low-risk, 24 ~ 45 for middle-risk, > 45 for high-risk), ADL scale [12] was used (Activities of daily living, ADL) to assess the ability of daily living activities (assessment indicators include eating, bathing, dressing, continence, toileting, bed-chair movement, walking flat, up and downstairs. The scale comes with a total score of 125, the lower the score is, the worse the self-care ability).

Biochemical indexes Levels of HbA1c, fasting blood glucose (FBG), triglyceride (TG), total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), serum calcium, alkaline phosphatase (ALP), serum creatinine (SCr), albumin (ALB), and 25 (OH) D were all collected in fasting state while 2 hours postprandial blood glucose (2HPBG) was collected after breakfast.

Statistical Analysis SPSS 22.0 was used to analyze the data, and the counting index was expressed as the adoption rate (%); Comparison of measurements was expressed as mean \pm standard deviation ($\bar{x} \pm S$). Chi-square test was used to compare the counting indexes. The measurements conforming to normal distribution were compared by two independent samples t test. Multivariate analysis adopts binary logistics regression analysis. Pearson correlation was used to study the correlation between the two measurement indexes, and Spearman correlation was used to study the correlation between the classification or grade indexes. All results were considered statistically significant at $P < 0.05$.

Results

Comparison of baseline data between fall group and non-fall group.

There were 38 patients in the fall group (male/female, 20/18), the average age is 64.75 (43-82) years, with average BMI being 23.17 (17.47, 29.55) kg/m². The average duration of diabetes was 11.9 years (0.15-33 years). A total of 38 cases of falling occurred, and the blood glucose was greater than 3.9 mmol/L in 9 cases, between 4 and 6 mmol/L in 21 cases, between 6.1 and 11.0 mmol/L in 8 cases, and higher than 11.0 mmol/L in 8 cases. There were no significant differences in age, gender, BMI, waist circumference, blood pressure and duration of diabetes between the two groups ($P < 0.05$), indicating that the data of the two groups are comparable, as shown in Table 1.

The difference analysis between the fall group and the non-fall group

1. Comparison and analysis of the differences of the measurements between two groups: The levels of FPG, LDL-C, ALP, the frequency of hypoglycemic events and MFS score in the fall group were higher than those in the non-fall group, while the levels of ALB, HDL-C and ADL score were lower than those in the non-fall group. 25 (OH) D and serum calcium levels in the fall group were lower than those in the non-fall group, but as with other measurements, there were no statistically significant differences between the two groups ($P>0.05$), as shown in Table 2.
2. Comparison and analysis of the differences of the countings between two groups:

The treatment rate of insulin or secretagogue and the rates of DN, DR, CKD, CI and OP in the fall group were higher than those in the non-fall group ($P<0.05$), and there were no statistical differences on other counting indexes between the two groups ($P>0.05$), as shown in Table 3.

Correlation study between fall and other variables

Fall was positively correlated with MFS score, treatment rate of insulin/secretagogue, frequency of hypoglycemic events, DN, DR, DKD, OP, FBG, LDL-C, ALP, and cerebral infarction (correlation coefficient $r>0$, $P<0.05$); 25 (OH) D, serum calcium, albumin, proprotein and HDL-C were negatively correlated (correlation coefficient $r<0$, $P>0.05$); Falls had no correlation with ADL score, DM duration, HbA1c, 2hPBG, SCr, TG, TC ($P>0.05$), as shown in Table 4.

Multivariate analysis of fall

Fall was taken as the dependent variable Y ($Y=1$ in fall group; $Y=0$ in non-fall group), other indicators such as the frequency of hypoglycemia during hospital stay was taken as independent variables X, and binary logistics regression was used to explore the risk factors affecting falls under the combined action of multiple factors. The analysis results revealed that cerebral infarction and HDL-C were the main risk factors for falling in T2DM inpatients, and the risk of falling was significantly increased in patients with cerebral infarction ($OR=21.738, P=0.029$), and the higher the HDL-C was, the lower the risk of falling was ($OR=0.021, P=0.002$), as shown in Table 5.

Discussion

Falls refer to unintentionally falling to the ground or a lower plane, which is the main cause of preventable injuries, even disability and death of the elderly [3]. Sibley et al. [15] demonstrated that 62% of people who fell had concurrent diseases, such as arthritis, visual impairments, hypertension, chronic obstructive pulmonary disease, diabetes or heart disease, and only 23.8% of them had a single chronic disease. T2DM patients hold a variety of metabolic disorders predisposing to hypertension, dyslipidemia, osteoporosis, ischemic cerebrovascular diseases, poor lower-extremity performance, and dysequilibrium. The risk of falls [13–14] and the proportion of hospitalization due to falls are both higher than non-DM patients [9, 10]. In our study, the incidence of DN, DR, CKD and CI in patients with T2DM in the fall group during hospitalization was significantly greater than that in the non-fall group, further verifying that comorbidity is an significant factor for falls [16].

Diabetic peripheral neuropathy(DPN) is the most common complication of diabetes mellitus, and the risk of falling is 4 times higher than that of ordinary diabetic patients [13], the risk will further increase along with more symptoms of DPN coming[17]. Apart from the sensation abnormality of pain, stress and temperature, DPN also complicates with plant nerve, cranial nerves, central nervous system lesions, leading to proprioceptive hypoesthesia. Besides, the coexistence of Dyslipidemia, hypertension, cerebral infarction with T2DM, the action of diabetic peripheral vascular disease and diabetic microangiopathy, will all intensify balance decline, leading to increased risk of falling due to instability of standing and acting [9,10,14]. Multi-factorial regression analysis illustrated that cerebral infarction was the main risk factor for falls, and the OR value was as high as 21.738, suggesting that T2DM combined with cerebral infarction significantly increased the risk of falls during hospitalization, which was further verified by this result. However, due to the small sample size, there was no significant correlation with other diseases. We can observe low albumin and HDL - C levels and high TC and LDL - C level is in the fall group, low albumin level is a risk factor for sarcopenia, which will affect the musculoskeletal system by reducing the synthesis of muscle protein. Patients with concurrent diabetes and dyslipidemia usually present with higher risk of sarcopenia. Multivariate analysis showed that lower levels of HDL - C is the main risk factor of falling. In general, early identification and rehabilitation training enhancement could help reduce the risk of falling during hospitalization.

Vision changes due to diabetic retinopathy(DR) will significantly increase the risk of falling in unfamiliar environment. Vitamin D deficiency and abnormal bone metabolism generated from Chronic nephropathy, along with the microstructural changes due to the crosslinking of collagen and advanced glycation end products result from chronic hyperglycemia increases the bone fragility, leading to the increased risk of osteoporosis. The proportion of concomitant DR and chronic nephropathy was higher in the fall group than that in the non-fall group, and the levels of 25(OH)D and serum Ca^{2+} are lower in the fall group while the ALP level was higher, indicating that the risk of osteoporosis is greater in the fall group. Researches revealed that vitamin D supplement contributed to the risk decrease of fall[18], but there was no significant differences in the 25(OH)D and serum Ca^{2+} levels between the two groups. Larger samples are needed to further discuss the relationship of Vitamin D and nosocomial fall.

Studies have shown that indoor falls are more likely to happen in deconditioned patients [19, 20]. The participants of our study are mostly recruited among elderly people, but middle-aged patients are also involved and falls were indoors mostly which indicated that middle-aged T2DM patients with non-multiple chronic diseases were also at high risk of falling. Therefore the fall prevention education should not only be focused on the elderly but also the middle-aged patients with multiple fall risks.

Apart from concomitant diseases, The internal factors of falls in diabetics also includes medication and reaction to medication such as insulin and hypoglycemia[4–7]. Hypoglycemia are the independent risk factor of fall-related fracture, and hypoglycemia-related falls are more likely to cause severe injury[6, 21, 22]. Retrospective cohort study have demonstrated that the risk of falling are greater in the T2DM patients group than in the non-DM group. Whether diabetes was treated or not was also significantly associated with the risk of falling. No matter the blood glucose level is below 3.9mmol/L or above 11.1mmol/L, frequency of hyperglycemia or hypoglycemia is also positively correlated with falls, which indicated nosocomial fall risk was increased no matter hyperglycemia, hypoglycemia or glucose fluctuation had been detected[23]. Glucose fluctuation brought by diabetes treatment of insulin or secretagogue can cause hypoglycemic reaction even though there was no hypoglycemia detect, and that increased the risk of falling eventually. Hence, potential fall risks should be

comprehensively considered when therapeutic regimen is developed. Treatment should be at low risk of hypoglycemia in order to reduce the falls due to glucose fluctuation.

External factors includes the progress that aggravate unbalance(e.g. glucose fluctuation, postural hypotension caused by anti-hypertensive agents, consciousness change result from psychotropic substances) and weakness of environmental design, care, communication, training and teamwork. The MFS scores were significantly higher in fall group but ADL scores were the opposite, which was in accordance with the prospective case study in Teheran[24]. Institutionalized T2DM patients with a history of falling, high MFS scores, visual impairment, disequilibrium, using of assistive devices, difficulties in defecation and urination, especially those with administration of anti-hyperglycemic and psychotropic substances have a high risk of falling during hospitalization. Early identification, enhanced fall prevention education and altering the risk factors of falling are essential. At the same time, guidance of hospital environment recognition will also be helpful to reduce the risk of falling.

Conclusion

In summary, T2DM inpatients have a higher risk of falling, especially those with glucotoxicity, multiple-complications, use of insulin and secretagogue, glucose fluctuation, and high prevalence of hypoglycemia. Falls of T2DM inpatients not only injure the musculoskeletal system but also aggravate the metabolic disorder and hypercoagulation due to the poor healing ability of this certain population. Besides, cardiovascular disease is also susceptible. Moreover, the prolongation of hospital stay and ascending risk of nosocomial infection will eventually bring more difficulties to the treatment and increase the hospitalization costs. The adverse event of falling will also have negative impact on the relationship between doctors and patients. Therefore, It is more essential to reinforce the identification of high-risk population, develop treatment and nursing rehabilitation plans after systematic evaluation, including reduction of glucose fluctuation, balance training enhancement, alleviation of the fear of falling, and improvement of the stability of walking.

Advantages And Limitations

The advantage of our study is the standardized evaluation of diabetic patients ,including the diagnosis of T2DM, DN, DR, CKD, CI and OP, the MFS and ADL scale[12]. The patients in fall group suffered indoor falling during hospitalization and their clinical characteristics and risk factors were fully assessed in our study.

As our study is retrospective, we chose the non-fall group patients based on the clinical data of age, sex and BMI that matched the fall group but with no falls during hospitalization. But the complications in this group might not fully represent the whole diabetes population. Prospective study with larger sample is needed in the future to evaluate the risk factors of falling during hospitalization, and the intervention of treatments and medical care strategy will be formulated to observe whether the time of falling will be shorter or not.

Declarations

Ethics approval and consent to participate: This study followed the ethical standards laid out in the Declaration of Helsinki 1964 and its later amendments or comparable ethical standards. The study was approved by the Medical Ethics Committee of Hainan General Hospital (Ethical approval number: Med-Eth-Re[2021] 129), and its

address is as follows: No.19 Xiuhua Road, Xiuying District, Haikou, Hainan, China. Since we only reviewed patient charts for our study, we pledged that we would not use the information for anything else other than research purposes. Hence the informed consent was waived by the Medical Ethics Committee of Hainan General Hospital.

Consent for publication☒Not applicable.

Availability of data and materials: The datasets analysed during the current study are available from the corresponding author on reasonable request.

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

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Authors' contributions: FW is responsible for the study design, process management and overall results analysis; JWY collected the clinical data and wrote the draft and the revised versions of the article; WJ, FW, LG, QJ also participated in the study design, data collection and results analysis; HBQ and KNC offered their helped on the collection of the clinical data and results analysis, also gave critical review on the manuscript. . All authors read and approved the final manuscript.

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***Conflict of Interest:** The authors declare that they have no conflict of interest

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Tables

Table 1 Selected Characteristics in fall and non-fall group

Variable	Non-fall group	Fall group	t/ χ^2	P
Age	62.13±12.95	64.76±11.31	-0.944	0.348
Duration of DM	10.61±6.34	11.9±9.25	-0.708	0.481
BMI	22.73±2.55	23.17±2.77	-0.735	0.465
Waist Circumstance	85.41±9.39	83.91±9.14	0.705	0.483
SBP	132.21±18.47	144.76±26.26	-1.587	0.117
DBP	73.63±11.73	79.37±14.43	-1.902	0.061
HR	83.76±12.75	86.71±12.79	-1.006	0.318
Gender Male	20/52.63	20/52.63	0.000	1.000

* BMI: Body Mass Index; SBP: Systolic Blood Pressure; DBP: Dialated Blood Pressure; HR: Heart Rate.

Table 2 Differences of measuring indexes between fall and non-fall group

Variable	Non-fall group	Fall group	t	P
Frequency of Hypoglycemia	0.21±0.62	1.3±2.31	-2.801	0.007
ADL	98.29±5.73	85±16.27	4.748	0.000
MSF	23.03±15.11	46.97±13.93	-7.184	0.000
25-OH-D	25.87±6.23	22.91±10.5	1.489	0.141
HbA1c	9.08±1.98	9.62±3.11	-0.903	0.369
FBG	7.95±2.74	10.48±3.82	-3.297	0.002
2hPBG	14.56±3.99	14.91±4.24	-0.363	0.718
Serum Ca	2.76±3.27	2.14±0.21	1.146	0.256
Serum Creatinine	68.71±26.47	97.68±95.41	-1.804	0.078
ALB	39.83±3.7	33.96±5.66	5.348	0.000
ALP	62.2±17.72	103.87±86.26	-2.917	0.006
TG	2.31±4.32	2.49±4.31	-0.182	0.856
TC	4.58±1.53	5.22±3.75	-0.982	0.329
HDL-C	2.59±1	1.16±0.5	7.895	0.000
LDL-C	1.36±0.36	2.53±0.88	-7.518	0.000

Table 3 Differences of counting indexes between fall and non-fall group

Variables		Non-fall group		Fall group		χ^2	P
		Case	Ratio(%)	Case	Ratio(%)		
Use of insulin/Secretagogue	N	11	28.95	4	10.53	4.07	0.044
	Y	27	71.05	34	89.47		
DN	N	22	57.89	6	15.79	14.476	0.000
	Y	16	42.11	32	84.21		
DR	N	37	97.37	24	63.16	14.037	0.000
	Y	1	2.63	14	36.84		
DKD	N	33	86.84	20	52.63	10.537	0.001
	Y	5	13.16	18	47.37		
CI	N	25	65.79	10	26.32	11.916	0.001
	Y	13	34.21	28	73.68		
OP	N	34	89.47	27	71.05	4.07	0.044
	Y	4	10.53	11	28.95		

* N: no; Y: yes.

Table 4 Correlation Analysis between fall and clinical indexes

Fall	DM Duration	Use of insulin/Secretagogue	Frequency of hypoglycemia	DN	DR	DKD	CI	OP
r	0.026	0.231	0.400	0.436	0.430	0.372	0.396	0.231
P	0.825	0.044	0.000	0.000	0.000	0.001	0.000	0.044
Fall	HbA1c	FBG	2hPBG	25-OH-D	Ca ²⁺	Creatinine	ALB	
r	0.032	0.347	0.032	-0.269	-0.319	0.090	-0.538	
P	0.781	0.002	0.785	0.020	0.005	0.439	0.000	
Fall	ALP	TG	TC	HDL-C	LDL-C	ADL	MSF	
r	0.360	0.091	0.052	-0.696	0.663	-0.600	0.622	
P	0.001	0.436	0.654	0.000	0.000	0.000	0.000	

Table 5 Multivariate Analysis of Binary Logistic Regression for Falling

variables	B	SE	Wald	P	Exp(B)	95.0%CI for Exp(B)	
						Lower	Upper
HDL-C	-3.857	1.238	9.708	0.002	0.021	0.002	0.239
CI	3.079	1.406	4.795	0.029	21.738	1.381	342.109

*CI: Cerebral Infarction.