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Blood Calcium as a Protective Factor against Traumatic Fracture

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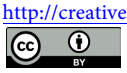

Abstract

Purpose: This study aims to investigate the predictive value of blood calcium in the prognosis of traumatic fracture. **Methods:** A retrospective experimental design was employed, 112 cases (52 non-fracture and 60 traumatic fracture) were randomly selected. The type of fracture complies with WHO-recommended (2019) diagnostic criteria for osteoporosis combined with fracture. The blood pressure (BP) was measured by OMRON's HEM-7136 model electronic blood pressure monitor. Blood calcium (Ca^{2+}), and blood phosphorus (P) values were measured using Colorimetric Roche kits on a Roche/Hitachi fully automated biochemical analyzer. Data collection and analysis followed. **Results:** Higher levels of age, systolic and diastolic blood pressures were found in the traumatic fracture group compared to the control group, whereas weight, height, and blood phosphorus did not differ significantly ($P < 0.05$). After adjusting for age, systolic blood pressure, diastolic blood pressure, and blood phosphorus, binary logistic regression analysis revealed that blood calcium was a protective factor against traumatic fracture ($\beta = -26.85$, $OR = 0.00$, 95% $CI = 0.00$ - 0.02, $P = 0.022$). **Conclusion:** The findings suggest that high and low blood calcium levels may serve as useful indicators in predicting the prognosis of fractures resulting from trauma.

Keywords

Traumatic Fracture, Fracture, Biochemical Indicators, Blood Calcium, Prognostic Value

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1. Introduction

Traumatic fractures can cause pressure sores, vascular nerve injury, deep vein thrombosis, soft tissue damage, etc. These variables can delay or prevent fracture healing, putting financial hardship on the patient, family, and society. In addition, there is no singular spot for traumatic fractures, such as upper and lower limb fractures, rib fractures, sternal fractures, radius fractures, femoral stem fractures, and numerous other types of fractures. In a study of 172 patients with traumatic fracture of the ankylosing spine, fracture-related spinal cord injury occurred in 57 (34.1%) patients [1]. In developed countries, trauma is the leading cause of death for individuals under 44 years old, and the leading cause is motor vehicle accidents [2]. Each year, 4 million patients in the United States are hospitalized for thoracic trauma [3]. The incidence of delayed fracture healing has been estimated between 10 and 15 percent [4]. Less than 30% of postmenopausal women and less than 10% of men with previous fractures receive treatment [5].

Blood calcium regulates the healing process of traumatic fractures in a significant way. In a study of alterations in calcium (Ca^{2+}) metabolism in haemophilia (PWH) patients, it was determined that biochemical markers of bone turnover could be used to detect bone loss [6]. Blood calcium and blood phosphorus are both biochemical markers of bone turnover. The parathyroid hormone (PTH), calcitonin (CT), and vitamin D3 are indicators of calcium and phosphorus metabolism regulation. A deficiency in vitamin D in conjunction with a low calcium intake may increase bone resorption and loss due to hyperparathyroidism, thereby increasing the risk of fracture. Human population pilot investigations found that dietary phosphorus alters mineral parameters acutely [7] [8]. Blood calcium performs vasodilation, diastole, nerve conduction, and glandular secretion. Calcium stored in bone is mobilized if dietary calcium intake is insufficient to sustain stable blood calcium levels in order to maintain calcium homeostasis.

By comparing data from patients with traumatic fractures and non-fracture controls, this project analyzes the changes in blood calcium during fracture healing. It provides a scientific foundation for exploring early patient risks and interventions to reduce the possibility of delayed healing and non-healing of fractures, providing early prevention and clinical treatment for patients at risk of fracture or at the stage of fracture, and reducing patient stress and doctor-patient disputes.

2. Materials and Methods

2.1. Subjects

Traumatic fracture and physical examination patients in Baise City hospitals from January 2018 to January 2022 were the study population. Traumatic fracture patients and physical examination population (without fracture) were randomly collected from the Affiliated Hospital of the Youjiang Medical University for Nationalities and other tertiary hospitals that met WHO-recommended (2019)

diagnostic criteria for osteoporosis combined with fracture. Traumatic extremity fractures are treated appropriately in the orthopaedic departments of the Affiliated Hospital of the Youjiang Medical University for Nationalities.

2.2. Disposal Process

There were a total of 112 cases were analyzed, with 52 belonging to the non-fractured group and 60 to the traumatic fracture group (Figure 1).

Inclusion criteria: Traumatic fractures require hospitalisation. The medical examination center's fracture-free patients. This survey and informed consent are voluntary.

Exclusion criteria: Drug-exposed patients. Diabetes mellitus, chronic liver and renal illnesses, and long-term hormonal medication treatment patients. Patients with severe cardio-cerebrovascular disease. Combination malignancies. Incomplete data.

2.3. Research Methods

This study sorted a random sample of eligible patients by admission time. At discharge, patients' gender, age, height, weight, underlying condition, type of fracture, blood pressure (BP), blood calcium (Ca^{2+}), and blood phosphorus (*P*) values were obtained. OMRON's HEM-7136 model electronic blood pressure monitor is available for purchase. Colorimetric Roche kits evaluated blood calcium and phosphorus levels on a Roche/Hitachi fully automated biochemical analyzer.

2.4. Statistical Analysis

The data were entered into Epi Data 3.0 software in pairs and exported to SPSS 25.0 statistical software. Multivariate adjusted analysis corrected for age, systolic, diastolic, and blood phosphorus for confounding factor analysis. The median (minimum to maximal values) was used for non-normal distribution data and

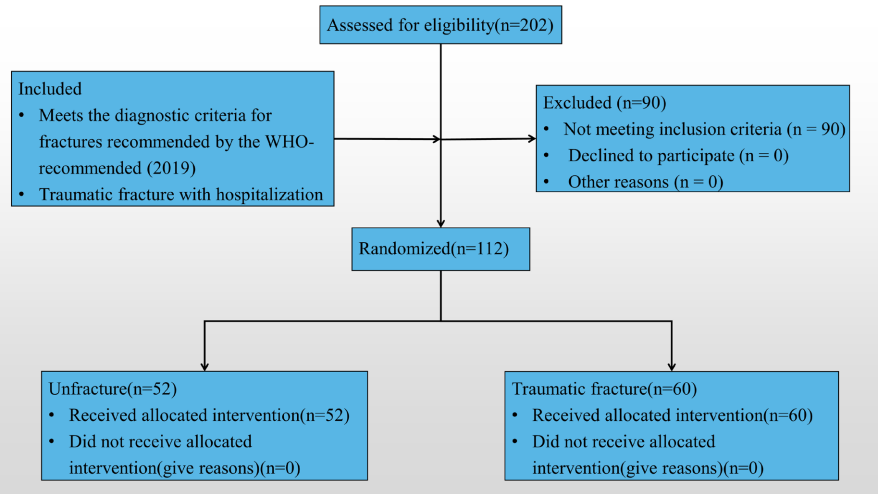

Figure 1. Flowchart showing the disposition of Participants in the study.

mean ± standard deviation ($\bar{X} \pm S$) for normal distribution data. Two independent samples t-tests were performed to compare groups and binary logistic regression was employed for influencing factors. $P < 0.05$ was significant.

3. Results

3.1. Patient Characteristics

By doing statistical analyses utilizing means and t-tests, we compared the baseline data for male and female patients and determined that there were greater levels of male weight (61.41 ± 10.50 kg) and height (1.65 ± 0.10 m) than female weight (53.98 ± 9.14 kg) and height (1.56 ± 0.06 m) ($P < 0.001$). The latter study did not take into account the influence of height and weight. Age, systolic blood pressure, diastolic blood pressure, blood calcium, and blood phosphorus comparisons revealed no statistically significant differences ($P > 0.05$) (Table 1).

3.2. Comparison of Multiple Body Components between the Groups Non-Fracture and Traumatic Fracture

The independent sample t-test revealed that significantly higher levels of age, systolic and diastolic blood pressure were found during traumatic fracture healing compared to the control group ($P < 0.001$), whereas height, weight, and blood phosphorus levels did not differ significantly from the control group ($P > 0.05$) (Table 2).

3.3. Comparison of Multiple Analysis between the Groups Non-Fracture and Traumatic Fracture

A binary logistic multifactorial regression analysis was employed to find out if blood calcium was a risk factor for traumatic fracture. With the presence or absence of traumatic fracture as the dependent variable and age, systolic blood pressure, diastolic blood pressure, blood calcium, and blood phosphorus as independent variables, the backward sequential method was utilized. Blood systolic pressure, blood diastolic pressure, and blood phosphorus were omitted from the model. Corrected age was a risk factor for traumatic fracture in the fracture group relative to the non-fracture group ($\beta = 1.33$, $OR = 3.77$, 95% $CI = 1.22$ - 11.65, $P = 0.021$), whereas blood calcium was protective against fracture ($\beta = -26.85$, $OR = 0.00$, 95% $CI = 0.00$ - 0.02, $P = 0.022$) (Table 3).

Table 1. Baseline data analysis of enrolled patients.

Gender	n	Age (years)	Weight (kg)	Height (m)	Systolic pressure (mmHg)	Diastolic pressure (mmHg)	Blood calcium (Ca^{2+}) mmol/L	Blood phosphorus (*P*) mmol/L
Male	57	45.51 ± 14.83	61.41 ± 10.50***	1.65 ± 0.10***	129.9 ± 17.88	78.49 ± 12.57	2.17 ± 0.13	1.06 ± 0.24
Female	55	50.98 ± 18.38	53.98 ± 9.14	1.56 ± 0.06	127.0 ± 21.96	74.91 ± 11.97	2.13 ± 0.14	1.06 ± 0.22
Total	112	48.20 ± 16.82	57.76 ± 10.49	1.60 ± 0.09	128.5 ± 19.95	76.73 ± 12.35	2.15 ± 0.14	1.06 ± 0.23

Note: Data are mean ± SD. Compared to the Female group ***$P < 0.001$.

Table 2. Comparison of multiple body components between the groups non-fracture and traumatic fracture.

Variables	Non-fracture	Traumatic fracture	F	T	*P*	95% *CI*	
						Lower limit	Upper limit
Age (years)	33.54 ± 4.57	60.90 ± 12.67	50.34	−15.60	<0.001	−30.85	−23.87
Weight (kg)	59.02 ± 10.30	56.67 ± 10.63	0.44	1.18	0.24	−1.58	6.28
Height (m)	1.60 ± 0.09	1.60 ± 0.09	0.75	0.10	0.92	−0.03	0.04
Systolic pressure (mmHg)	119.94 ± 16.67	135.97 ± 19.69	1.89	−4.61	<0.001	−22.92	−9.13
Diastolic pressure (mmHg)	72.37 ± 10.56	80.52 ± 12.62	1.57	−3.67	<0.001	−12.55	−3.75
Blood phosphorus (P) mmol/L	1.08 ± 0.24	1.04 ± 0.22	0.01	0.84	0.4	−0.05	0.12
Number	52	60	-	-	-	-	-

Note: 95% CI = 95% confidence interval. Compared to the two groups. The difference was highly significant at $P < 0.001$.

Table 3. Analysis of independent influencing factors of traumatic fracture.

Variables	*β*	S. E.	Wald	V	*P*	*OR*	95% *CI* of *OR*	
							Lower limit	Upper limit
Age (years)	1.33	0.58	5.29	1.00	0.021*	3.77	1.22	11.65
Blood calcium (Ca^{2+}) mmol/L	−26.85	11.73	5.24	1.00	0.022*	0.00	0.00	0.02

Note: Variables inputted in step 1: age (years), systolic blood pressure (mmHg), diastolic blood pressure (mmHg), blood calcium (Ca^{2+}) mmol/L, blood phosphorus (*P*) mmol/L. S. E. = Standard Error; *OR* = Odds ratio; 95% *CI* of *OR* = 95% confidence interval of OR. Traumatic fracture group compared to Non-fracture group *$P < 0.05$.

4. Discussion

Calcium (Ca) is a vital mineral for sustaining strong bones. The body can obtain calcium via food, calcium supplements, or create it through exercise. When the concentration of calcium in the blood is low, calcium is released from the bones into the bloodstream, which may threaten bone health [9]. Thus, it may be deduced that there is a correlation between the concentration of calcium in the bloodstream and the process of bone fracture recovery. The primary factors responsible for regulating blood calcium levels are 1,25-dihydroxy vitamin D3 ($1,25(OH)_2D_3$), parathyroid hormone (PTH), and fibroblast growth factor 23 (FGF23) [10] [11] [12]. Lower calcium levels can cause a rise in PTH, which stimulates the release of calcium ions from the skeleton into the blood, enhances the excretion of phosphorus by the kidneys, and regulates the balance of calcium and phosphorus in the blood [13] [14]. One study found that taking growth hormone, calcitonin, and calcium supplements raised bone mass [15]. This study retrospectively analysed the relationship between serum calcium levels and traumatic fractures. The findings revealed that corrected age and blood calcium levels were lower in individuals with traumatic fractures than in controls.

Fracture rates are projected to rise annually due to the expanding geriatric demographic and improved transit accessibility. Calcium supplements can enhance musculoskeletal health and decrease the risk of fractures caused by falls. Another study that looked at two years found that older people who ate calcium and protein from high-calcium, high-protein dairy products had a 33% lower risk of any fracture, a 46% lower risk of hip fracture, and an 11% lower risk of falling [16]. Blood calcium levels and metabolic regulation markers are frequently utilised in researching osteoporotic fractures. Previous studies have demonstrated a significant correlation between gender, age, bone mineral density, and bone turnover markers with the occurrence of osteoporotic vertebral compression fractures [17] [18]. Nevertheless, research on traumatic fractures, particularly among populations residing in southwest China, is nonexistent. As a result, looking for biochemical indications connected to the healing of traumatic fractures in the clinic can be useful in addition to analysing various clinical outcomes and determining the prognosis of fracture patients.

Calcium is necessary to activate and regulate osteoblast (cell lineage) and promote bone mineralization and bone strength. Hypoparathyroidism can be treated every day with synthetic human PTH 1-34 (hPTH 1-34), which changes the shape of the iliac crest bones and promotes bone conversion [19]. This is consistent with the results in the present study, blood calcium is a protective factor for traumatic fractures. Intriguingly, some studies have shown that long-term calcium and vitamin D supplementation appears to not affect bone strength [20] [21].

This suggests that the effects of supplements may be contingent upon certain conditions, such as the supplement's dosage and duration, a combination of physical activity and other supplements, adequate rest, a light diet, and other factors. These mechanisms collectively support the notion that blood calcium levels contribute significantly to fracture prevention. Additionally, investigating the interplay between blood calcium and other factors, such as vitamin D and parathyroid hormone, may provide valuable insights into the complex mechanisms underlying fracture susceptibility.

Due to individual differences, calcium and vitamin D absorption, along with that of other nutrients circulating in the body, varies. According to the available evidence, these nutrients do not affect bone health. Therefore, to reduce the incidence of traumatic fractures, it is essential to take precautions, prevent falls, and increase physical activity.

5. Limitations

Individual variability, additional diseases, low patient acceptance, and the restricted number of samples in this study may affect results. This trial did not alter blood calcium levels in traumatic fracture patients, and we expect future studies will. Future clinical research will concentrate on utilizing biochemical indicators of bone metabolism to predict traumatic fracture changing patterns.

6. Conclusion

Age increases traumatic fracture risk, but serum calcium protects. The study suggests that blood calcium levels can predict traumatic fractures. This may aid in fracture recovery prediction.

Consent to Participate

All experiments were validated to have been conducted by the applicable nomenclature guidelines and regulations. It was made sure that all participants and/or their legal guardians gave their informed permission.

Ethical Approval

All procedures performed in studies involving human participants were by the ethical standards of the institutional and/or national research committee and with the World Medical Association's (WMA) 1964 Helsinki Declaration and its later amendments and/or comparable ethical standards. The Medical Ethics Committee of the Youjiang Medical University for Nationalities reviewed and approved all experiments (approval number: 20230601001).

Consent for Publication

All authors have given their consent to publish.

Availability of Supporting Data

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors' Contributions

Xin Zhang: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing—original draft; Quanquan Zhang: Data curation, Funding acquisition, Investigation, Project administration, Resources; Tao Feng: Investigation, Software; Yinjun Luo: Investigation, Software; Yue Hu: Formal analysis; Ying Li: Formal analysis, Project administration; Wenjing Yu: Formal analysis, Project administration; Linghan Guo: Technical guidance, Data analysis; Suchan Liao: Methodology, Supervision, Validation; Jinhua Wang: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing—review & editing.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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