Two Key Symptoms For Detecting Vertebral Compression Fracture Among Elderly People With Acute Low Back Pain

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Ikemoto T. conceived and designed the study, collected data, analyzed the data, and prepared the draft and tables.

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The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of Aichi Medical University (2021-034). The requirement for written consent was waived for subjects evaluated during the study period unless they refused to provide the information according to the withdrawal strategy.

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Abstract

Introduction: This study aimed to investigate whether difficulties in some motions concomitant with increased spinal loads would distinguish between patients with and without fresh vertebral compression fractures (VCFs) in elderly patients with acute low back pain.

Methods: Of the 85 screened patients aged 65 years and older, 80 eligible participants were enrolled. Participants were asked about difficulties (none, slightly, and extreme) in getting up and rolling over and then divided into the VCF group or the non-VCF group after imaging examinations. A logistic regression model was used to determine whether the following variables were associated with the presence of fresh VCFs: age, sex, pain duration, pain severity, and difficulties in getting up and rolling over. Then, a multivariate stepwise logistic regression model was used to determine which variable correlated with the presence of fresh VCFs. Subsequently, we created a key symptom score for the presence of fresh VCFs, and discrimination of fresh VCFs was tested using the receiver operating characteristic (ROC) curve.

Results: In the multivariate logistic regression analysis, difficulties in getting up ($p < 0.05$) and rolling over ($p < 0.01$) were associated with VCFs after controlling for age, sex, and pain severity. As we weighted with 0, 1, or 2 to assess the severity of key symptoms, the score ranged from 0 to 4. The ROC curve showed that scoring of the two key symptoms significantly discriminated participants with or without VCFs with an area under curve = 0.88 ($p < 0.001$). A score of 2 on the key symptom score showed a sensitivity of 97%, and a score of 4 showed a specificity of 95% for fresh VCFs.

Conclusions: The results indicate that there may be specific symptoms in elderly patients with fresh VCFs. Scoring of the two key symptoms may be useful for screening fresh VCFs in this population.

Keywords: Vertebral compression fracture; Osteoporosis; Screening

1. Introduction

Low back pain (LBP) and osteoporosis are common health problems among the aging population worldwide. Vertebral compression fractures (VCFs) are often encountered in elderly patients who complain of LBP. Previous Japanese studies conducted in 1988¹ and 2012–2013² reported that the prevalence of VCFs was associated with increasing age. VCFs in elderly people are known to be associated with not only LBP but also later functional disability³, impaired quality of life⁴, and increased mortality^{5,6}. Fink et al. reported that approximately one-fourth of incident radiographic vertebral deformities were clinically diagnosed as new VCFs⁷.

Acute LBP is encountered as a frequent symptom in elderly people; however, it has been reported that VCFs are often overlooked in the physical examination and even when plain radiographic assessments are performed^{8,9}, even though VCFs have the largest number of serious pathologies in the spine among elderly people¹⁰. In recent years, it is well known that magnetic resonance imaging (MRI) is a very sensitive tool for detecting vertebral edema as a result of VCFs¹¹. Since MRI exams require time and expense⁹, it is desirable to develop a simple screening tool for detecting fresh VCFs. However, to date, little attention has been focused on the specific symptoms of fresh VCFs in previous studies.

Thoracolumbar VCFs are known to be associated with LBP and limitation of movement in elderly patients; however, the severity of these symptoms in patients changes over time and often improves in a few weeks. Hence, patients, as well as clinicians, are not aware whether the symptoms are signs of VCFs or not. Conversely, several studies suggest that increased spinal loads would worsen pain symptoms in patients with VCFs^{10,11}. Additionally, Sfeir et al. have reported that some yoga poses with

spinal flexion and/or spinal rotation should be avoided to reduce the risk of VCFs in elderly people¹². Thus, we hypothesized that pain symptoms might worsen with increased spinal loads in patients with fresh VCFs, and these could be screening signs for detecting fresh VCFs in elderly people.

This study aimed to investigate (1) whether differences in the difficulty of some motions concomitant with increased spinal loads would distinguish between patients with and without fresh VCFs and (2) whether scoring of symptom severity could be a screening tool for detecting fresh VCFs in elderly patients with acute LBP.

2. Materials and Methods

2-1. Study design

This is a cross-sectional study, and data were obtained from patients' reports in medical records.

2-2. Ethics

The study was approved by the Institutional Research Ethics Board. The requirement for written consent was waived for subjects evaluated during the study period unless they refused to provide the information according to the withdrawal strategy.

2-3. Key symptoms in fresh VCFs

We searched for typical symptoms of VCFs using the PUBMED/MEDLINE database. The following symptoms among people with fresh VCFs were retrieved from the literature: limitations of spinal movement, back pain with position changes, and back pain with coughing, sneezing, or lifting¹³; the keyword “symptoms become worse with spinal movement” then emerged. Additionally, Finucane et al. reported the following features in representative patients with VCFs: “A 35-year-old man showed that he has limited thoracic spine movement into rotation to both sides,” and “a 60-year-old woman presented with pain during extension and rotation”¹⁰.

Subsequently, we hypothesized that difficulty in the following behaviors could be different between subjects with and without fresh VCFs.

- (1) Difficulty in getting up
- (2) Difficulty in rolling over

The subjects were asked which distress they felt about the above movements in the following degree: None, Slightly, or Extreme. The scores were weighted with 0, 1, or 2 according to the degree of severity (**Supplement**).

2-4. Variables related to VCF

It is well known that aging in older people is a risk factor for VCFs, especially in women, and that pain severity is usually expected to be intense when spinal fractures occur. Additionally, the number of days after pain onset is expected to affect the severity of the symptoms. Therefore, age, sex, pain duration, and subjective pain severity were determined as variables associated with VCFs. An 11-point numeric rating scale was used to measure pain severity of LBP, where 0 = no pain and 10 = worst pain imaginable.

2-5. Eligibility

The inclusion criteria for this study were as follows: (1) acute LBP within 4 weeks and (2) age ≥ 65 years. The exclusion criteria were as follows: (1) radiating pain in the unilateral leg or both legs, (2) presence or history of major neurological disorders such as poststroke or Parkinson's disease, (3) high-energy trauma, (4) ongoing malignant disease, (5) pyogenic spondylitis, and (6) dementia.

2-6. Subjects

Subjects in this study were recruited from the outpatient ward of our hospital between January 2020 and June 2021. Patients with acute LBP were asked about their degree of distress in getting up and rolling over behaviors before any image examination. Image examinations such as plain radiography, computed tomography (CT), and MRI were

performed to diagnose the cause of back pain. On the basis of image examinations, the subjects were allocated into the following two groups: the non-VCF group and the VCF group. Those who did not meet the eligibility criteria were excluded from each group.

2-7. Diagnosis criteria for fresh VCF

The diagnosis of fresh VCF was based on the presence of any of the following findings on X-ray, CT, or MRI: (1) discontinuity of cortical lines of vertebrae on X-ray or CT and/or (2) abnormal intensity of the vertebral body on MRI¹⁴. The presence of fresh VCFs was determined when fractures occurred between the Th10 and L5 vertebral bodies. For the non-VCF group, the absence of fracture was confirmed when abnormal vertebral body intensities were not detected on MRI.

2-8. Sample size

It is generally believed that a sample size of at least 30 is needed in a study. Thus, we first analyzed the first 30 eligible cases; we found that there were 16 cases in the non-VCF group and 14 cases in the VCF group (approximately 1:1 allocation). As we hypothesized that a cut-off point of scoring could discriminate between non-VCF and VCF, the receiver operating characteristic (ROC) curve was used to detect this value. The area under the ROC curve (AUC) is an effective method for summarizing the overall diagnostic accuracy of a test. Generally, an AUC of 0.5, which suggests no discrimination, whereas 0.7–0.8 is considered acceptable¹⁵. For an AUC of 0.7, a two-tailed α level of 0.05, a power (1- β) of 0.9, and a 1:1 allocation, the minimum number of subjects was estimated to be 40 for each group. Finally, 40 participants per group (a total of 80) were recruited in the order of their visits to our clinic.

2-9. Statistics

Continuous variables are represented as mean and standard deviation, or medians and interquartile range, whereas categorical variables are represented as the number and percentage of patients. Variables between the two groups were compared using the Chi-square test, Student's t-test, or Mann–Whitney U test.

A logistic regression model was used to determine whether the following variables were associated with the presence of fresh VCFs: age, sex, pain duration, pain severity, and difficulties in getting up and rolling over. Then, a multivariate stepwise logistic regression model was used to determine which variable correlated with the presence of fresh VCFs.

A key symptom score was determined by the sum of the scores that were significantly associated with fresh VCFs. Subsequently, the discrimination of fresh VCF was tested using the ROC curve, and AUC, sensitivity, and specificity were calculated according to the degree of the key symptom score. Generally, an AUC of 0.5 suggests no discrimination, 0.7–0.8 is considered acceptable, 0.8–0.9 is considered excellent, and more than 0.9 is considered outstanding¹⁵. Analyses were performed using JASP software version 0.15 (<https://jasp-stats.org/>) and SPSS software (version 25, SPSS Inc., Chicago, IL, USA). All results were considered statistically significant at $p < 0.05$.

3. Results

3.1. Characteristics and severity of the symptoms

Eighty-five patients with acute LBP were screened, and five patients were excluded because of the eligibility criteria (Figure 1). Regarding participant characteristics, there

were no statistical differences in age, sex, and pain duration between the two groups, whereas pain severity, difficulty in getting up, and difficulty in rolling over statistically differed between the two groups (Table 1).

3.2. Related variable to fresh VCF

In univariate logistic regression models, pain severity ($p < 0.001$), difficulty in getting up ($p < 0.001$), and difficulty in rolling over ($p < 0.001$) were associated with the presence of fresh VCFs (Figure 2). A multivariate stepwise logistic regression revealed that difficulties in getting up ($p = 0.025$) and rolling over ($p = 0.001$) were significant predictors associated with fresh VCF (Table 2). As key symptoms detecting fresh VCF included difficulties in getting up and rolling over, the key symptom score ranged from 0 to 4.

3.3. Discrimination value of the key symptom score for fresh VCF

The ROC analysis showed that the key symptom score discriminated VCFs and non-VCFs excellently, with an AUC of 0.88 ($p < 0.001$) (Figure 3). Table 3 shows the metrics of the key symptom scores for fresh VCF. A score of 2 on the key symptom score showed a sensitivity of 97%, and a score of 4 showed a specificity of 95%, suggesting that a score of 2 or higher is unlikely to rule out a fresh VCF, whereas a score of 4 indicates a high likelihood of fresh VCF.

4. Discussion

This study hypothesized that difficulties in some motions concomitant with increased spinal loads would be associated with fresh VCFs and that the scoring of symptom severity could be a screening tool for detecting fresh VCFs in elderly patients with acute LBP. We found that difficulties in getting up and rolling over were significant predictors of fresh VCFs. Additionally, scoring of the above two symptoms may be useful for screening fresh VCFs in this population.

Although pain severity of LBP was associated with the presence of fresh VCFs in a univariate analysis, this was no longer significant in the multivariate analysis. We found that advanced age (odds ratio = 1.09) would be a candidate contributor to fresh VCF, although the p-value was slightly less than the significance level. Considering that the present study consisted of a small sample, our results are consistent with previous epidemiological findings that older age is associated with a greater susceptibility to VCFs. Nevertheless, our results did not show that women were more likely to have fresh VCF than men. In a recent epidemiological study, although women were overall more susceptible to VCF than men, sex differences in the prevalence of VCF varied according to the severity of compression and age group². Thus, the lack of sex differences in the occurrence of fresh VCFs in the present study might be explained by sampling bias (e.g., small sample size).

Previous studies have reported that typical symptoms of fresh VCFs include sudden onset of back pain, increased pain during standing and walking, and decreased pain during lying¹⁴. However, in clinical practice, these symptoms do not seem to be specific to patients with fresh VCFs. Difficulties in getting up and rolling over may also not be specific symptoms in fresh VCFs, but we thought that these behaviors would clearly increase the spinal load and thus worsen the severity of the patient's feeling. Expectedly,

we found that difficulties in getting up and rolling over were significantly associated with fresh VCFs. Interestingly, the odds ratio predicting fresh VCF was higher for difficulty in rolling than for getting up, suggesting that trunk twisting motion may be more sensitive in detecting bone insult than trunk flexion motion.

The strength of the present study is that we found specific symptoms in elderly patients with fresh VCFs, and scoring of the two key symptoms may screen fresh VCFs in an elderly population. Recent advances in musculoskeletal research have revealed that routine imaging is not associated with clinically meaningful benefits but can lead to harm^{16,17} and overuse of imaging also contributes to increasing costs associated with LBP¹⁸. Notably, however, considering that VCFs are one of the red flags in acute LBP in elderly people, our findings shed light on the symptomatology of VCFs and may contribute to the further development of this field.

This study has several limitations. First, bone mineral densities and known risk factors associated with VCFs^{19,20} were not considered. Combining these relevant factors may provide more accurate results. Second, since the subjects of this study were limited to the elderly aged 60 years or older, it is unclear whether the present results apply to those under 60 years of age. Third, the sample size was relatively small, and a larger sample size would be preferred. Additionally, recruitment of the participants from only a single institute in this study may not reflect all characteristics of fresh VCFs; hence, a multicenter study that includes different geographic regions is required.

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Figure legends

Figure 1. Flow diagram of participants.

Figure 2. Estimate plots of each variable for fresh VCF using univariate analysis.

Each plot shows the probability of fresh VCFs on relevant parameters. Gray zones and error bars indicate a 95% confidence interval. Fresh VCF was significantly associated with pain severity, difficulties in getting up ($p < 0.001$), and rolling over ($p < 0.001$).

Age, sex ratio, and pain duration were not associated with fresh VCFs.

Figure 3. ROC curve for the key symptom score to discriminate between the VCF group and the non-VCF group.

235x165mm (600 x 600 DPI)

Each plot shows probability of fresh VCFs on relevant parameters. Gray zones and error bars indicate 95% confidence interval. Fresh VCF was significantly associated with pain severity, difficulties in getting up ($p < 0.001$), and rolling over ($p < 0.001$). Age, sex ratio, and pain duration were not associated with fresh VCFs.

327x149mm (600 x 600 DPI)

167x174mm (600 x 600 DPI)

Table 1. Characteristics and severity of the symptoms.

	Non-VCF group (n = 40)	VCF group (n = 40)	p-value
Age (years)	76.7 [7.6] [#]	79.5 [8.3] [#]	0.11
Female (n)	25 (62.5%)	28 (70.0%)	0.48
Pain duration (days)	7.0 [8.75] [§]	7.5 [11.0] [§]	0.97
Pain severity (NRS)	5.0 [2.0] [§]	7.0 [3.0] [§]	<0.01
Difficulty in getting up (n, 0:1:2)	2 : 29 : 9	0 : 7 : 33	<0.01
Difficulty in rolling over (n, 0:1:2)	13 : 24 : 3	1 : 11 : 28	<0.01

[#] mean and standard deviation

[§] medians and interquartile range

NRS, numerical rating scale

Table 2. Predictors associated with fresh VCF using multivariate analysis.

Variables	Odds ratio [95% CI]	p-value
Difficulty in rolling over (0, 1, 2)	8.56 [2.33, 31.46]	0.001
Difficulty in getting up (0, 1, 2)	5.03 [1.24, 20.39]	0.024
Age (years)	1.09 [1.00, 1.20]	0.053
95% CI, 95% confidence interval		

Table 3. Metrics of the key symptom score for fresh VCF.

Key symptom score	Odds ratio	Odds ratio 95%CI	p-value*	Sensitivity	Specificity
2	18.78	2.32–152.17	0.006	97.5%	32.5%
3	21.00	6.46–68.28	<0.001	87.5%	75.0%
4	35.29	7.39–168.48	<0.001	65.0%	95.0%

95% CI, 95% confidence interval

*p-value was analyzed using the Wald *test*.