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Research Article

Construction and Validation of a Risk Warning Model of Depression in Patients with Pulmonary Nodule

Jiaojiao Sun,[1] **Yunxu Zhou,**[1] **and Zhiqiang Wang** [2]

[1]*Wuxi School of Medicine, Jiangnan University, Wuxi, China*
[2]*Department of Cardiothoracic Surgery, Affiliated Hospital of Jiangnan University, Wuxi, China*

Correspondence should be addressed to Zhiqiang Wang; wxsywzq@163.com

Background. To establish a depression risk warning model for patients with pulmonary nodules and to provide a theoretical basis for medical staff to identify high-risk patients early and quickly and take timely intervention measures. *Methods.* A total of 535 hospitalized patients with pulmonary nodules were selected, and the relevant data were analyzed by single-factor analysis. Binary logistic regression analysis was used to determine the independent risk factors for depression in patients with pulmonary nodules and to establish a risk warning model. The Hosmer−Lemeshow test and receiver operating characteristic (ROC) curve were used to evaluate the goodness of fit and prediction effect of the model, and the cross-validation method was used to verify the efficacy of the model. *Results.* The prevalence of depression in patients with pulmonary nodules was 47.29%. Univariate analysis showed that CRP, albumin, creatinine, phosphorus, calcium, triglyceride, cholesterol, low-density lipoprotein, high-density lipoprotein, β2-microglobulin, objective support, social support, and education level were related to depression in patients with pulmonary nodules ($P < 0.05$). Binary logistic regression analysis showed that serum CRP, calcium, social support, and education level were independent risk factors for depression in patients with pulmonary nodules. The area under the ROC curve/sensitivity/specificity of serum CRP, calcium, social support, and education level was 0.78/86.88%/80.65%, 0.79/84.40%/75.59%, 0.83/89.91%/80.22%, and 0.81/85.96%/79.19%, and the accuracy of cross-checked risk warning model was 84.97%. In the Hosmer−Lemeshow test, $P = 0.926$, area under the ROC curve was 0.98, sensitivity was 98.17%, and specificity was 93.55%. The accuracy of the cross-checked risk warning model was 84.97%, indicating that the prediction effect of the model was good. *Conclusions.* Serum CRP, calcium, social support, and education level are the independent risk factors of depression in patients with pulmonary nodules, and the risk warning model based on them has a good early warning effect on depression in patients with pulmonary nodules. The risk warning model established in this study has a good predictive effect on depression in patients with pulmonary nodules.

1. Introduction

Nowadays, with the advancement of people's living standards, the continuous improvement of health awareness, and the widespread use of low-dose computed tomography (LDCT), pulmonary nodules are most discovered during physical examination [1]. By chest radiography or chest CT examination, most pulmonary nodules are difficult to distinguish between benign and malignant, and such patients usually require outpatient follow-up for more than 2 years to observe changes in the nodules and determine whether further treatment is required [2, 3]. Most pulmonary nodules do not progress to lung cancer, but because of the first

discovery and long-term follow-up, patients may encounter significant stress, adverse emotional changes, and distress. A high level of illness uncertainty reduces patients' quality of life and treatment effect and has a significant impact on their prognosis [4, 5]. According to studies [6, 7], 40% of patients with pulmonary nodules experience anxiety and depression, whereas this proportion is only 7% in healthy physical examiners who do not have pulmonary nodules. Anxiety and depression symptoms in patients with pulmonary nodules can lead to immune dysfunction and inflammation [8, 9]. As a result, it is critical to actively seek predictive tools that correspond to the depressive characteristics of patients with pulmonary nodules. Through a case-control study, this study

investigated the risk factors associated with pulmonary nodules depression and developed a risk early warning model to help the medical staff determine the risk of depression in patients early and quickly, early identification of high-risk groups and nursing intervention.

2. Objects Participants and Methods

2.1. Research Objects Participants. Patients with pulmonary nodules who were admitted to Cardiothoracic Surgery at Jiangnan University's Affiliated Hospital between January 1, 2020, and October 10, 2021, were chosen as research subjects. The following were the inclusion criteria: ① patients with pathological diagnosis of pulmonary nodule; ② Age ≥18 years; ③ Understand the disease; ④ Have normal language expression ability and comprehension ability and agree to participate in the study. Exclusion criteria: ① have a personality disorder or patients already using psychotropic medications; ② complicated with serious cardiovascular, liver, and kidney diseases or malignant tumors; ③ patients diagnosed with mental illness before illness; ④ Patients who had participated in psychological intervention in the past 3 months. Informed consent was obtained from all patients.

2.2. Research Methods

2.2.1. Recruitment and Data Collection. After selecting our research subjects according to our inclusion and exclusion criteria, we had one-on-one communication with the research subjects to explain our research content and the significance of our research. According to the Helsinki Declaration, verbal informed consent of the participants was obtained before the start of our study. Patients were evaluated using the self-rating depression scale, and patients with a score lower than 50 were defined as the nondepression group, and those with a score higher than 50 were defined as our depression group.

The patients' general information background information was gathered, which included: gender, age, education level, monthly household income per capita, profession, patient source, type of health care, drinking, smoking, marriage, total score for social support, these data were obtained through interviews with patients; family history of mental illness, the history of surgery, the history of chronic illness, tumor related history, staging, number of chemotherapies, whether the transfer, serum CRP, albumin, serum creatinine, phosphorus, calcium, β2 microglobulin, triglycerides, total cholesterol, tow-density lipoprotein, high-density lipoprotein, these data were obtained by reviewing hospital medical records and obtaining consent from the hospital field. Before data collection: two researchers who had received standardized training explained the meaning of scale items and notes for filling out the scale to patients one by one using unified instructions. Adopt effective communication methods to ensure the accuracy of data. Data collection and entry: At least two researchers must be present at the same time to ensure the data's validity and completeness. After data collection: Data cannot be changed for any reason. Effective means of communication have been employed to ensure the accuracy of the data. Data collection and entry: At least two investigators have been present at the same time to ensure data validity and completeness. After data collection: Data have not been changed for any reason. Convenience sampling was used in this study. In this study, 550 questionnaires were distributed, 545 were recovered, 10 invalid questionnaires were eliminated, and 535 valid questionnaires were obtained, yielding an effective rate of 97.73%.

2.2.2. Instruments

(1) The Self-Rating Depression Scale (SDS) was developed by Zung in 1965 [10, 11], and SDS includes 20 items that assess symptoms of depression. Participants rated each item based on how they felt during the previous week. Item responses were scored on a four-point rating scale (1–4), a higher SDS score indicates a higher level of depression. The sum of the scores of the 20 items was the total score, which was multiplied by 1.25 to obtain the SDS index score. The Chinese version of SDS was published in the late 1980s. According to the Chinese SDS Manual [12], people with a score of ① 50–59 were classified as mild depression; ② 60–69 were classified as moderately to significantly depressed; ③ Individuals with scores of 70 and above were classified as having severe to extreme depression. In the present study, Cronbach's alpha was 0.81.

(2) The Social Support Rating Scale (SSRS) is used to assess the perception of social support and satisfaction with this social support, which was developed by Xiao [13, 14] according to the environmental and cultural conditions in China. It consists of 10 items, including objective support (3 items), subjective support level (4 items), and social support utilization (3 items). Items 1–4 and 8–10 were scored on a four-point scale (1–4 points). Item 5 was divided into five sub-questions, and each sub-question was graded from "none" to "full support" on a 1–4-point scale. For items 6 and 7, points were given according to the number of sources in the "following sources." If the answer was "no source," the score was 0. The higher the total score, the higher the overall social support. The score was 0. The higher the total score, the higher the overall social support. ≥45 was defined as high support [15]. The scale has been widely used in the Chinese population and has been shown to have high reliability and validity [16, 17]. In the present study, the sums of total scale and three subscales were calculated. The Cronbach's α value of the scale, 0.86, indicated good internal consistency.

2.3. Statistical Analysis. For data analysis, SPSS 25.0 was used. We used the χ^2 tests and the logistic regression analysis. To assess the predictive value of each independent index and the risk, early warning model, on the depression of pulmonary nodule patients, the receiver operating

characteristic (ROC) curve was used. The risk early warning model's efficiency was tested using the leave-one-out cross-validation method.

3. Results

3.1. The Status of Depression in Patients with Pulmonary Nodule. Among 535 pulmonary nodule patients, 253 had depression, including 122 males and 131 females ranging in age from 23 to 79 years, with an average age of (60.51 ± 12.09) years. 282 had no depression, including 130 males and 152 females ranging in age from 22 to 81 years, with an average age of (59.20 ± 12.33) years. Patients with pulmonary nodules had a depression prevalence of 47.29% (253/535).

3.2. Univariate Analysis of Depression in Patients with Pulmonary Nodule. According to the SDS, the patients were divided into two groups: the non-depression group and the depression group, and the results show statistically significant differences ($P < 0.05$). As shown in Table 1.

3.3. Depression in Pulmonary Nodule Patients: A Binary Logistic Regression Analysis. The variables with statistical differences were considered independent variables (assign the following education levels: elementary school or lower = 0, junior high school = 1, senior high school or higher = 2; continuous variables included CRP, albumin, serum creatinine, phosphate, calcium, triglyceride, cholesterol, low-density lipoprotein, high-density lipoprotein, $\beta2$ micro globulin, objective support, social support, and enter the initial value); Depression as a dependent variable (depression = 0; non-depression = 1), serum CRP, calcium, social support, and education level were discovered to be independent risk factors for depression in pulmonary nodules patients ($P < 0.05$). As shown in Table 2.

3.4. Construction of Risk Warning Model of Depression in Patients with Pulmonary Nodule. ROC curve was used to analyze the factors that entered the logistic regression equation. The results showed that the area under the curve/sensitivity/specificity of serum CRP, calcium, social support, and education level were found to be 0.78/86.88%/80.65%, 0.79/84.40%/75.59%, 0.83/89.91%/80.22%, 0.81/85.96%/79.19%, respectively. As shown in Figure 1.

The risk warning model formula was developed by using the above variables B as coefficients in the logistic regression model. $P = 1/\{1 + \exp[-(-0.03 \times \text{serum CRP} + 1.32 \times \text{calcium} + 0.42 \times \text{social support} - 4.20 \times \text{education level (middle school)} - 3.00 \times \text{education level (high school and above)} - 30.59)]\}$. The predicted probability value was calculated using the predicted probability as the diagnostic variable and the occurrence of depression as the status variable. The results showed that the area under the ROC curve of the risk early warning model was 0.98, the cut-off value was 0.43, and the sensitivity and specificity were 98.17% and 93.55%, respectively. As shown in Figure 2. The

result of the Hosmer-Lemeshow deviation test was $\chi^2 = 0.462$, $P = 0.926$, indicating that the model was well-calibrated.

3.5. Efficiency Test of Risk Warning Model. Taking depression as a categorical variable and the predicted probability value as an independent variable, the consistency between the predicted depression grouping and the measured depression grouping of the warning model was tested. The results showed that the classification accuracy of the risk warning model was 84.97%. As shown in Table 3.

4. Discussion

4.1. Statement of Principal Findings. Depression can hurt patients' quality of life as well as the disease's therapeutic effect. Patients with pulmonary nodules often struggle to distinguish between benign and malignant pulmonary nodules, and because of their lack of understanding of the disease and their fear, such patients frequently suffer from major depression [18]. This study discovered that patients with pulmonary nodules had a high level of depression, with a 47.29% incidence. This study's depression risk prediction model confirmed that serum CRP, calcium, sleep quality, social support, education level, and quality of life all had a direct predictive effect on depression.

4.2. Risk Factors of Depression in Patients with Pulmonary Nodules. Inflammation caused by pulmonary nodules and depression is linked. Inflammation causes more severe depression and a lower likelihood of surviving [19]. CRP is an acute phase response protein that can be indicative of congenital inflammation. CRP has been given the most attention and has been linked to depression [20]. CRP and proinflammatory cytokines [21, 22] are two biomarkers that have been linked to depression.

Because the diet is a modifiable risk factor for depression, dietary changes may reduce the burden of depression [23]. Adopting healthy dietary patterns that correspond to food-based dietary recommendations and nutritional needs is critical for preventing, slowing, or controlling the progression of depressive symptoms and promoting optimal mental health [24].

Emotional disorders are frequently associated with sleep disorders. Sleep disorders are not only the most common pre-depression symptoms, but they can also predict the occurrence and outcome of depression [25]. Suicidal ideation and attempt are independent predictors of sleep disorder [26]. At the same time, depression can exacerbate sleep problems, and sleep and depression have a two-way predictive effect [27].

There is also a link between the degree of depression and the quality of life [28]. Pulmonary nodule patients have a lower quality of life, and most of them experience negative emotions, primarily anxiety and depression. The more severe the depression, the lower the quality of life of pulmonary nodule patients [29]. By improving patients' psychological adaptation level, social support can alleviate

TABLE 1: Univariate analysis of depression in patients with pulmonary nodule.

Variable	The non-depression group ($n = 282$)	The depression group ($n = 253$)	Statistic	P value
Gender			2.13	0.144
Male	130	122		
Female	152	131		
Age (years)	59.2 ± 12.33	60.51 ± 12.09	0.76	0.451
Education level			34.88	<0.001
Primary and lower grades	81	104		
Secondary school	77	92		
High school and up	124	57		
Monthly household income per capita (YUAN)			0.16	0.984
<1000	26	85		
1000–2990	67	70		
3000–4999	76	67		
>5000	113	31		
Profession			0.03	0.987
Unemployed/retired	60	135		
Farmers	113	49		
Worker/individual/other	109	69		
Patient source			3.44	0.179
Rural	67	132		
County/town	78	67		
City	137	54		
Type of health care			0.07	0.966
Self-paying	68	146		
New rural cooperative medical system	89	48		
Medical insurance for urban workers	125	59		
Drinking			0.14	0.934
Occasionally	77	61		
Yes	91	156		
No	114	36		
Smoking			0.03	0.855
Yes	93	178		
No	189	78		
Marriage			0.03	0.987
Divorced or widowed	67	186		
Married	150	55		
Unmarried	65	12		
Family history of mental illness			2.81	0.094
Yes	105	186		
No	177	67		
The history of surgery			0.02	0.891
Yes	113	198		
No	169	55		
The history of chronic illness			1.84	0.175
Yes	84	149		
No	198	104		
Tumor related history			0.11	0.740
Yes	91	178		
No	191	75		
Pathological classification			0.09	1.000
Adenocarcinoma	104	40		
Squamous cell carcinomas	95	48		
Small cell lung cancer	52	67		
Other	31	98		
Staging			3.61	0.307
I	93	32		
II	83	35		
III	65	88		
IV	41	98		
Number of chemotherapies			1.49	0.684

TABLE 1: Continued.

Variable	The non-depression group (n = 282)	The depression group (n = 253)	Statistic	P value
1	105	21		
2	76	36		
3	67	87		
4	34	109		
Whether the transfer			0.14	0.705
Yes	91	187		
No	191	66		
Total score for social support	30.11 ± 3.22	25.54 ± 3.52	−9.64	<0.001
Objective to support	9.31 ± 1.49	7.19 ± 1.759	−9.27	<0.001
Subjective support	9.32 ± 2.29	9.65 ± 2.13	1.31	0.301
Utilization of support	9.32 ± 2.29	8.70 ± 2.34	−1.91	0.058
Serum CRP (mg/L)	26.89 ± 34.22	62.80 ± 57.41	5.28	<0.001
Albumin (g/L)	33.28 ± 7.82	29.85 ± 8.00	−3.08	0.002
Serum creatinine (μmol/L)	62.00 ± 14.34	55.38 ± 12.52	−3.46	0.001
Phosphorus (mmol/L)	1.51 ± 0.53	1.70 ± 0.51	2.58	0.011
Calcium (mmol/L)	2.17 ± 0.49	1.93 ± 0.60	−3.07	0.003
β2 microglobulin (mg/L)	2.80 ± 1.16	3.34 ± 1.27	3.14	0.002
Triglycerides (mmol/L)	1.82 ± 1.60	2.34 ± 1.56	2.34	0.021
Total cholesterol (mmol/L)	5.23 ± 1.17	5.69 ± 1.19	0.91	0.007
Low-density lipoprotein (mmol/L)	3.64 ± 0.88	3.96 ± 0.95	0.43	0.015
High-density lipoprotein (mmol/L)	1.23 ± 0.40	1.09 ± 0.49	−2.11	0.036

TABLE 2: Binary logistic regression analysis of depression in patients with pulmonary nodules.

Variables	Regression coefficient	Standard error	Wald chi-square values	P	OR value point estimation
Education level			18.39	<0.001	
Primary and lower grades					
Secondary school	−4.19	0.98	18.37	<0.001	0.015 (0.002, 0.103)
High school and up	−2.99	1.27	5.52	0.019	0.050 (0.004, 0.609)
Objective to support	0.48	0.29	2.62	0.106	1.609 (0.904, 2.862)
Serum creatinine (μmol/L)	0.02	0.04	0.35	0.555	1.023 (0.948, 1.104)
β2 microglobulin (mg/L)	−0.52	0.30	2.97	0.085	0.597 (0.332, 1.073)
Total cholesterol (mmol/L)	0.19	0.35	0.32	0.574	1.214 (0.616, 2.393)
Triglycerides (mmol/L)	−0.34	0.25	1.89	0.169	0.709 (0.435, 1.157)
Phosphorus (mmol/L)	−0.99	0.83	1.43	0.232	0.373 (0.074, 1.882)
Albumin (g/L)	0.05	0.06	0.76	0.384	1.051 (0.939, 1.176)
Total score for social support	0.42	0.16	6.76	0.009	1.527 (1.110, 2.102)
Low-density lipoprotein (mmol/L)	−0.36	0.47	0.60	0.440	0.695 (0.276, 1.750)
High-density lipoprotein (mmol/L)	1.52	0.82	3.43	0.064	4.591 (0.914, 23.061)
Calcium (mmol/L)	1.32	0.67	3.93	0.048	3.734 (1.014, 13.746)
Serum CRP (mg/L)	−0.03	0.01	10.11	0.001	0.973 (0.956, 0.989)
Constant	−30.59	7.60	16.21	<0.001	

depressive symptoms in pulmonary nodule patients [30], obtain more social support, and effectively relieve anxiety and depression in pulmonary nodule patients [31]. Perceived social support assists pulmonary nodules patients in developing effective coping strategies to cope with the disease. Perceived social support can help patients not only reduce their economic burden but also establish confidence in overcoming the disease and cultivate a positive and optimistic attitude, which is conducive to eliminating negative emotions and promoting disease improvement [32].

There are differences in the prevalence of depression among pulmonary nodules patients with varying levels of education. Patients with a high education level can learn in a variety of ways, have a clear and scientific understanding of their disease, communicate more smoothly with medical staff, and reduce their psychological burden; patients with a low education level have fewer available social resources and are more likely to suffer from depression [33]. Such patients should be given special attention in clinical settings.
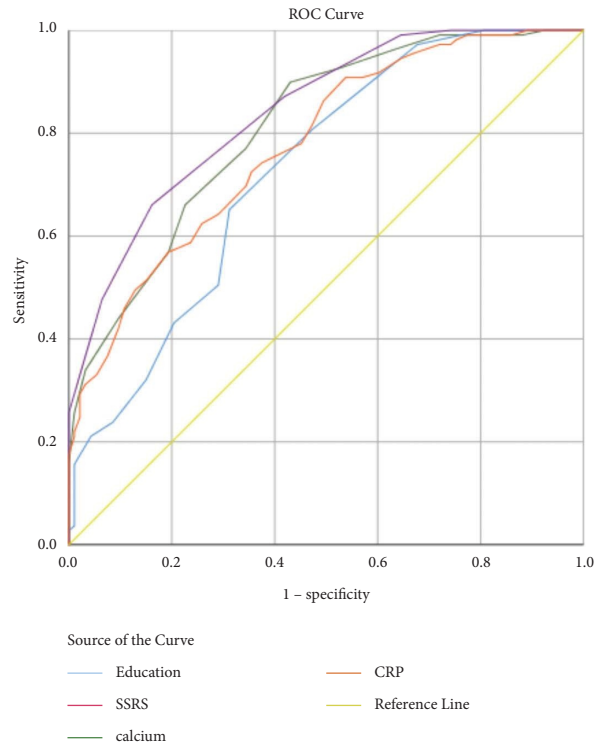
FIGURE 1: ROC curve of serum CRP, calcium, social support, and education level.
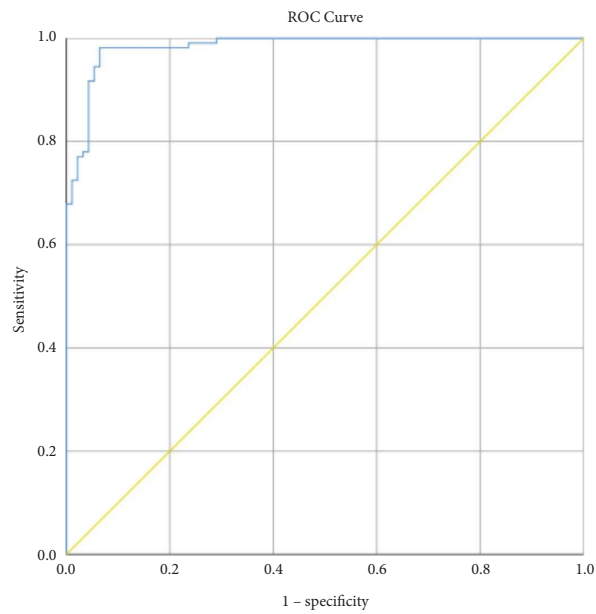

FIGURE 2: ROC curve of the risk warning model of depression in patients with pulmonary nodules.

TABLE 3: Efficiency test of risk warning model.

The measured depression grouping	The predicted depression grouping			
	The non-depression group		The depression group	
	The number of incidents	The percentage (%)	The number of incidents	The percentage (%)
The non-depression group	82	87.23	12	12.77
The depression group	11	18.64	48	81.36

4.3. Implications for Policy, Practice and Research. Due to the high incidence of depression in patients with pulmonary nodules and its negative consequences, there is an urgent need for a rapid and operable method to conduct risk screening for such patients, but there are few similar studies now. The risk warning model of depression in patients with pulmonary nodules developed in this study consisted of six components: serum CRP, calcium, sleep quality, social support, education level, and quality of life. The area under the ROC curve was 0.98, which was greater than the predictive efficacy of independent risk factors, and the diagnostic sensitivity and specificity were respectively 98.17% and 93.55%. The diagnostic value outperforms a single index. After cross validation, the prediction accuracy of the model was 85.92%. In general, the model has a good predictive ability for the early judgment of depression risk of patients, and medical staff can put forward more appropriate nursing measures according to the model in the follow-up work to improve the treatment effect of patients. To summarize, serum CRP, calcium, sleep quality, social support, education level and quality of life are independent risk factors for depression in patients with pulmonary nodules. The risk warning model developed because of this is highly operable and reliable, with superior diagnostic efficacy when compared to a single indicator. It can be used to quickly determine whether patients with early pulmonary nodules are at risk for depression.

5. Strengths and Conclusions

The risk prediction model of depression in patients with pulmonary nodules developed in this study has good prediction efficiency, and the data are convenient and easy to obtain, making it useful for risk assessment and depression prevention in patients with the pulmonary nodule. Clinical staff should conduct early assessment and intervention based on the factors that influence depression, improve information mastery in patients with pulmonary nodules, and reduce the occurrence of depression in patients with pulmonary nodules.

Data Availability

The data that support the findings of this study are available from the author upon reasonable request.

Conflicts of Interest

The authors have disclosed that they do not have any potential conflicts of interest.

Authors' Contributions

Wang contributed to the study design and oversight of the project. Sun and Zhou performed all the studies. Sun wrote the manuscript and contributed to revisions of the manuscript. Wang contributed significantly to data collection, algorithm design, and experiments. Sun was responsible for the design of the whole project and the final revision and finalization of the paper. All the authors have read and approved the manuscript for publication.

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