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A Comparative Study of Logistic Regression Model in Color Doppler Ultrasound Diagnosis of Breast Cancer

Jianping Wu[a], Sulai Liu[b], Yaoping Tang[c], Hongfei Xu[d], Xiaoming Chen[e*]

Abstract

Objective To establish a logistic regression model based on the breast imaging report data system (BI-RADS) to evaluate the diagnostic efficiency of breast cancer risk prediction.

Methods a retrospective analysis of 1660 cases of breast ultrasound image data from January to September 2011 was carried out. The image features were standardized according to BI-RADS standard, and the pathological results were taken as the gold standard. A logistic regression model was established by integrating the ultrasound image features of diagnostic value into univariate analysis, to explore the sensitivity, specificity and accuracy of the model in predicting the risk of breast cancer.

Results single factor analysis showed that 18 of the 30 ultrasound image features had statistical significance in differentiating benign and malignant breast diseases ($P < 0.001$). The sensitivity, specificity and accuracy of the logistic regression model based on these image features were 84.5%, 95.5% and 91.4%, respectively. The area under the working characteristic curve of the subjects was 0.964, and the prediction accuracy was 91.0%.

Conclusion the logistic regression model based on the characteristics of BI-RADS ultrasound image has a good diagnostic efficacy in predicting the risk of breast cancer, which indicates that the big data of standardized breast ultrasound report can establish a clinical decision-making system for breast cancer, and assist ultrasound doctors to improve the diagnostic level.

Keywords: Ultrasound; breast image reporting data system; logistic regression model

1. Introduction

The incidence rate of breast cancer is the highest in China(Gulanbaier et al.,2010;Leng et al.,2015; Wilder-Smith ,2011;Ying ,2013;Sladkevicius and Jokubkiene, 2007). High frequency ultrasound (HFUS) is the first choice of imaging technology in the rural breast cancer screening project designated by the former Ministry of health, and plays an important role in the diagnosis and differential diagnosis of breast cancer(Schelling ,1997;Tailor et al.,1997; Czekierdowski et al.,2000;okubkiene et al.,2007). The breast imaging report data system (BIRADS) was established in 2003 by the American College of Radiology on the basis of the X-ray breast imaging report and data system-Quasi assessment classification can objectively reflect the characteristics of breast masses, which is conducive to the differential diagnosis of breast benign and malignant diseases(ASLAM ,2000;Zhang et al.,2019 Epstein etal.,2002). In this study, large samples of breast ultrasound image and text data were standardized by BI-RADS. Single factor and multi factor Logistic regression analysis were carried out for malignant signs, and regression model was established to predict the risk of breast disease according to the ultrasonic conclusion.

[a,c,d,e] Hunan University of Science and Engineering, Yongzhou 425100, Hunan, PR China
[b] HunanProvincial People's Hospital, Hunan, PR China
**Corresponding author: Xiaoming Chen*
E-mail: 45737620@qq.com

2. Data and methods

2.1 General data

The general data were included in the breast mass patients who were examined by ultrasound and confirmed by pathology in Hunan Provincial People's Hospital in January and September 2011. All the patients were women. The double examination cases were deleted by Excel. The cases with incomplete ultrasound or pathological data and the cases with clinical intervention were deleted when analyzing the data. Finally, 1660 patients, aged 12-86, with a mass diameter of 4-150 mm were included.

2.2 method

The ultrasound images of patients were included in the retrospective analysis. According to the evaluation and classification guidance of BIRADS, the ultrasound image features of patients were standardized, Standardized description includes shape (regular, irregular), orientation (parallel to the surface skin, not parallel to the surface skin), edge (limited, fuzzy, angulated, lobulated, hairpin sign), boundary (clear, unclear), strong echo halo, internal echo, peripheral tissue change (catheter abnormality, per ligament traction, structural distortion, edema, skin thickening, retraction), posterior retraction Whether the sound is attenuated, whether there is microcalcification in the mass, whether there is a small cluster cyst, whether there is a complex cyst, whether there is a mass in the skin, whether there is a foreign body in the breast, whether there is detection of the intramammary lymph nodes, whether the axillary lymph nodes are enlarged, Adler classification of blood flow, flow velocity and resistance index. The blood flow classification is I1 or above, and resistance index ≥ 0.7 is the malignant indicator 5.

3 Results

3.1 Distribution of pathological types

In the 1660 patients with breast masses, 1041 were benign and 619 were malignant, see from Fig.1.

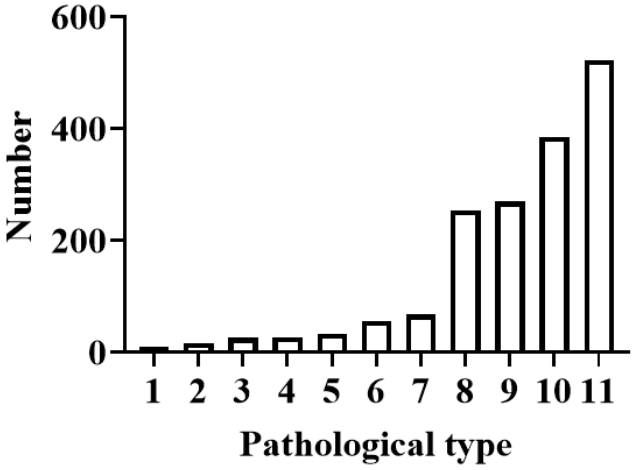

Figure 1. **1660 cases of breast masses**

3.2 Single factor analysis of image feature diagnosis efficiency

Shape, orientation, edge blur, angulation (Figure 2), lobulation, prick sign (Figure 3), boundary, hyperechoic halo, structural distortion (Figure 4, Cooper ligament traction thickening (Figure 5), edema, skin thickening and retraction, posterior retraction and attenuation, microcalcification in mass, axillary lymph node enlargement, blood flow the 18 signs of Adler classification, flow velocity and resistance index were significantly different between benign and malignant groups ($P < 0.001$).

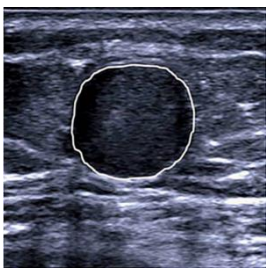

Figure 2. **Some ultrasound features of breast cancer. Angular sign in breast cancer showing a round shape**

Figure 3. **Some ultrasound features of breast cancer and "burr" sign in breast cancer, showing an irregular** shape

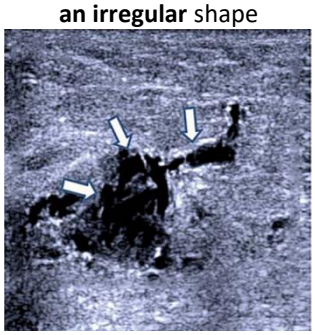

Figure 4. **Ultrasound features of breast cancer "structural distortion" in breast cancer (arrows)**

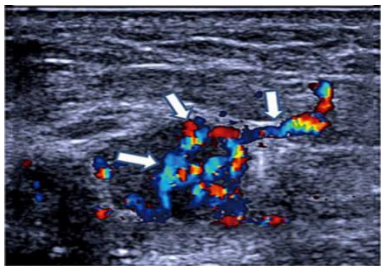

Figure 5. **Some ultrasound features of breast cancer. Opal ligament thickening(arrow) in breast cancer on color Doppler flow imaging.**

3.3 Multi factor analysis of image feature diagnosis efficiency

After assigning 18 indexes with statistical significance in single factor analysis, they were included in multi factor Logistic analysis. For the assignment. A logistic regression model was established for the diagnosis of benign and malignant breast lesions by ultrasound. Draw ROC curve (Figure 6) with the predicted value, calculate the prediction ability of the area evaluation model under the curve. The sensitivity, specificity and accuracy of the logistic I regression model based on these image features are 84.5%, 95.5% and 91.4% respectively. The area under the curve is 0.964, the standard error is 0.005, P < 0.0001, and the 95% confidence interval is shown in Figure 7.

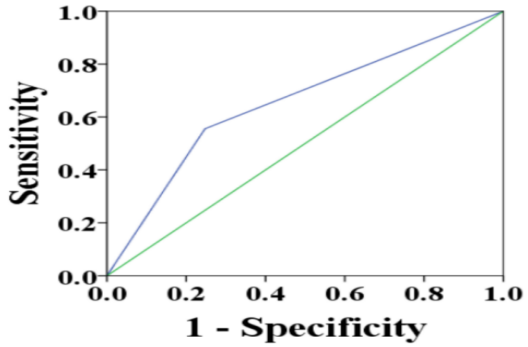

Figure 7. **ROC curve of logistic regression equation**

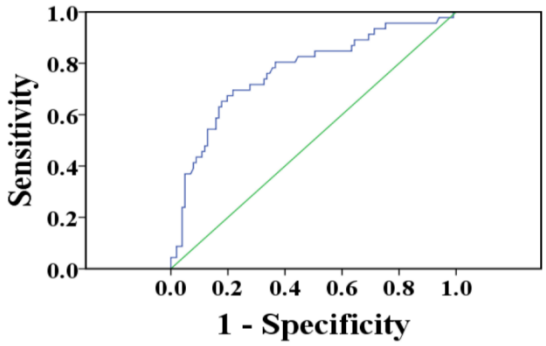

Figure 6. **Multivariate logistic analysis of the differential diagnosis between benign and malignant breast masses**

3.4 Discussion

Breast cancer has become the highest incidence rate of malignancy in China. There is currently no primary prevention measure(Francesco et al.,1999;Michael et al.,2003;Wang et al.,2012;MOU etal.,2012). Early detection and early treatment are still the most important factors affecting the prognosis of breast cancer(Valentin eta.,2001;Zhang etal.,2011). Ultrasound is an important method for the differential diagnosis of breast cancer. There are not a few reports, but most of them have some problems, such as less samples, incomplete ultrasound image features, and irregular description(Njalalle et al.,1998;Marret ,2001).

In this study, large sample cases were included. Firstly, the ultrasound reporting terms of each case were standardized by BI-RADS, and 30 ultrasound image features including 18 aspects were included in the study(Madja et al.,2011). Through single factor analysis, there were statistically significant differences in shape, orientation, edge, boundary, hyperechoic halo, surrounding tissue changes, whether the echo in the back was attenuated, whether there was microcalcification in the mass, whether the axillary lymph nodes were enlarged, Adler classification of blood flow, flow velocity and resistance index in the differentiation of breast benign and malignant diseases (P < 0.05)(Yu ,2013;

Bonilla-Musoles etal.,1995; Hur Kyu Yeon et al.,2018). The features were regular shape, orientation parallel to the surface skin, limited edge, clear boundary, Adler grading of blood flow, flow velocity < 20cm / s, resistance index < 0.7, which were more expressed in benign breast lesions; The signs are irregular, the orientation is not parallel to the surface, the skin is fuzzy, angulated, lobulated, burr sign, the boundary is not clear, strong halo, Cooper ligament is pulled, the structure is distorted, edema, skin thickening, retraction, echo attenuation at the back, microcalcification in the mass, axillary lymph node enlargement, Adler grade of blood flow is II-III, flow rate ≥ 20 cm / s, resistance index ≥ 0.7 is more expressed in breast cancer, which is called ultrasound malignant sign, which is similar to the previous results(Clayton et al.,2005;Smet and Brabanter ,2006;Weizheng et al.,2006).

Or value is the ratio of the number of exposed and non-exposed patients in the case group and the number of exposed and non-exposed patients in the control group. It can be used as an estimate of

relative risk(Chen ,2010). It is an indicator of the intensity of association between exposure factors and patients with the disease. When or > 1, the greater the value, the stronger the association between the factor and the disease. In this study, the value of or indicates the ratio of the risk of breast cancer with and without a certain ultrasonic image feature(Yan-Fang et al.,2014). The higher the value of or > 1, the more likely the mass is to be breast cancer with this feature. In univariate analysis, the or values of 18 ultrasound malignant signs ranged from large to small: Cooper ligament traction > hyperechoic halo > skin thickening > axillary lymph node abnormality > structural distortion > burr sign > irregular shape > Blur > edema > incomplete boundary > resistance index ≥ 0.7 > microcalcification > angulation > flow rate ≥ 20cm / S > echo attenuation at the back > azimuth non parallel > lobulation, The first six of them were formed by the changes of the surrounding tissues, which corresponded to the invasive growth pattern and lymphatic metastasis of breast cancer(Chen ,2013). The features of ultrasound images included in previous studies are not complete, and the signs of Cooper ligament traction, nodule distortion and skin thickening and retraction are often ignored. 1. In this study, these signs or value is high, and the specificity of independent diagnosis of breast cancer is more than 90%, which is a very good indicator of ultrasound diagnosis of breast cancer.

4 Conclusion

This study included a large sample of cases, through the single factor analysis, define the ultrasound benign and malignant signs, evaluate the effectiveness of ultrasound malignant signs in the differential diagnosis of breast benign and malignant diseases, and the regression model established by multi factor analysis has a good prediction ability for breast cancer. The results of this study indicate that the prediction model with evidence-based medicine significance can be used in the clinical decision support system of breast ultrasound, and assist ultrasound doctors to improve the diagnosis level of breast cancer.

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