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Research Progress of Ultrasound Radiomics in The Diagnosis and Treatment of Breast Cancer

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Abstract: With the advancement of medical research in recent years and the frequent occurrence of different types of cancer, breast cancer has gradually attracted the public's attention. The incidence of breast cancer is rising, mainly affecting women with a high mortality rate. According to the clinical treatment effect, early diagnosis and early treatment can effectively control the mortality of breast cancer and improve patient's quality of life. Ultrasound radiomics is an emerging field that can extract quantitative high-dimensional data from ultrasound images. Recently, ultrasound radiomics has been widely used in the clinical treatment of breast cancer. This paper analyzed the research progress of ultrasound radiomics in the diagnosis and treatment of breast cancer.

Keywords: Ultrasound radiomics; Breast cancer; Diagnosis and treatment; Research progress

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1. Introduction

According to statistics, breast cancer currently has the highest incidence rate among female cancers, ranking second in mortality. With the changes in people's lives and eating habits, more young people are being affected [1]. The reason is that whether it is one's lifestyle, genetic inheritance, or occupational habits, these will have a certain impact on the incidence of breast cancer. If breast cancer is detected early, corresponding treatment measures can be taken to effectively improve the survival rate of patients. Medical imaging examination is one of the main methods of non-invasive diagnosis and treatment in the early stages of breast cancer. Patients can monitor the development of the disease through magnetic resonance imaging (MRI), ultrasound, and mammography. Doctors can also intuitively analyze the specific characteristics of the tumor through medical images. However, the inspection method is invisible, hence it is necessary to use image processing algorithms to mine and analyze the data. Radiomics methods can solve such problems to a certain extent. In this paper, the research progress of ultrasound radiomics in the diagnosis and treatment of breast cancer was reviewed and analyzed [1].

2. Overview of radiomics

2.1. Research on core concepts

In 2012, Lambin *et al.* [2] first mentioned the term "radiomics." Radiomics mainly uses the current advanced data mining technology. Some information or characteristics in medical impact can be transformed into quantitative data so that doctors can evaluate the disease progression of patients according to the tumor genotype and phenotype characteristics. To some extent, radiomics can provide support for the clinical treatment of tumors and also contribute to the realization of precision medicine.

2.2. Research on radiomics

(1) Data acquisition: According to the existing research design, the information in medical image data was uniformly collected and image acquisition can be performed by X-ray, computed tomography (CT), or ultrasound (US).

(2) Image segmentation: As the name implies, segmentation is the division of an area into several different areas. The image segmentation mentioned here outlines the tumor area in the medical image, and the specific segmentation method can be artificial, semi-automatic, or automatic segmentation.

(3) Feature extraction: Feature extraction involves the application of data mining technology, which requires a combination of mathematical calculation and a specific type of image to extract the specific information process. Currently, the widely used features of radiomics include first-order gray histogram features or intensity features, second-order texture features, etc.

(4) Feature selection: With the help of data mining technology, the system uses the preset mathematical algorithm for high-dimensional feature data The data is processed to reduce the dimension, and the processes with low correlation and redundancy are removed to ensure the accuracy of the results.

3. Application of ultrasound radiomics features in breast cancer

3.1. Research on ultrasound radiomics in the diagnosis of breast cancer

The application of mammography is now extremely common in clinical diagnosis and treatment, which plays an irreplaceable role in the treatment of breast-related diseases. However, as the majority of Chinese women's breasts are dense, the X-ray images tend to overlap, resulting in false positives or false negatives. Although the practical value of ultrasound radiomics has been affirmed, the results are still affected by the subjective experience of the operators. Benign breast lesions are usually oval or round, with smooth boundaries and uniform echo. Malignant tumors are usually lobulated, or spiculated, with uneven echo. It should be noted that when the malignant tumor is in the early stage, the image features of the malignant tumor may overlap. If the attending doctor is inexperienced, it may cause misdiagnosis and delay in treatment [4]. Ultrasound radiomics can play a role in the quantitative analysis of the evidence-based region of interest (ROI), which can obtain a lot of disease-related information. At the same time, it can also detect lesions that are difficult to see with the naked eye, which improves the accuracy of tumor diagnosis. Currently, many studies have shown that ultrasound radiomics can significantly improve the accuracy of differentiating between malignant and benign breast tumors. For example, one study applied the adaptive boost algorithm, selected more than 100 breast cancer patients, and concluded that tumor traits and echo pattern characteristics could distinguish tumor lesions.

3.2. Research on ultrasound radiomics for molecular typing of breast cancer

Currently, immunohistochemistry (IHC) is generally used to determine whether breast tumors are malignant or benign. If biopsy or surgical specimens are used, only a small number of tumor samples can be obtained, and some of the larger tumors will hinder the acquisition of information due to their heterogeneity [6–8]. The ultrasound characteristics of each molecular subtype of breast cancer are significantly different. Molecules and cytokines can also cause changes in the morphological or biological characteristics of the tumor, and some of these changes can be observed by ultrasound. Previous studies have found that quantitative indicators based on ultrasound imaging have higher accuracy in detecting the expression of hormone receptors in breast cancer [9]. It was also found that compared with HER2-positive and HER2-positive breast cancer cells, triple-negative breast cancer has higher solid density, larger posterior density, and a smoother border, suggesting that there are differences in different subtypes of breast cancer. Liu *et al*. used AdaBoost technology to extract and analyze the feature parameters of 104 breast tumors from the three levels of morphology, texture, and wavelet, which preliminarily confirmed that the bioinformatics quantitative representation method based on ultrasound imaging can effectively evaluate the endocrine function of breast cancer patients [10]. Tumor progression is closely related to the neovascularization at the tumor site. Neovascularization is the core link of the occurrence and development of a variety of malignant tumors, which has an important impact on tumor proliferation and invasion. Ki-67 is a nuclear protein that is highly expressed in proliferating cells, also known as nuclear proliferators. Our previous study found that the expression level of Ki-67 in breast cancer was closely related to the occurrence, development, metastasis, and prognosis of breast cancer. Through the quantification of 3D color image data of 76 breast cancer patients, Wang *et al*. confirmed that there was a significant correlation between vascularization index (VI), VFI (VFI), and Ki-67 expression, suggesting that 3D color image quantification technology could accurately evaluate the blood supply of breast cancer.

3.3. Research on axillary lymph node metastasis to the axilla

The axillary lymph node (ALN) is a key indicator affecting the prognosis of breast cancer patients. Currently, the diagnosis of ALN still relies on surgical resection and tissue sections, which inevitably leads to increased surgical complications. Therefore, early detection and systematic treatment of ALN are of great significance in reducing the mortality of patients. Sentinel lymph node puncture (SLN) is an effective method to detect ALN in early breast cancer. Based on the radiomics analysis of 343 primary breast cancer lesions, Gao *et al*. constructed a mathematical model to evaluate the distribution of axillary lymph nodes in T1/T2 breast cancer [3]. Through the analysis of patient age, lesion size, and radiomics, ideal results were obtained, and the area under the characteristic curve (AUC) reached 0.84. Based on the analysis of 843 images of breast masses, Zhou *et al*. established a deep neural network model that could evaluate the status of ALN for non-invasive auxiliary diagnosis [13]. Ultrasonographic images of patients with breast tumors can be used to make a preliminary diagnosis according to the characteristics of the extracted ultrasonographic images.

3.4. Studies on the evaluation of breast cancer chemotherapy

Neoadjuvant chemotherapy (NAC) is the main treatment for advanced breast cancer. Compared with traditional adjuvant therapy, not only can NAC reduce lesions but also improves efficacy and achieves a pathological complete response [14]. Currently, MRI-based imaging technology is an important means to evaluate the efficacy of breast cancer and determine the survival rate of patients. Previous studies have shown that ultrasound imaging can be used to evaluate the therapeutic effect of NAC. DiCenzo *et al*. [4] adopted the preadaptation imaging technique (QUS) to construct an early warning model of breast cancer. Our previous study showed that QUS imaging technology can be used to evaluate the sensitivity of NAC in patients with advanced breast cancer (LABC), and preliminarily demonstrated that ultrasound imaging technology can be used to judge the efficacy of NAC [15]. Lowerison *et al.* [5] established a new method for the quantitative evaluation of tumor hemodynamic parameters, which can be used to evaluate the vascular recovery after NAC to better reflect the efficacy of NAC. By using a QUS index of 53 breast cancer patients undergoing neoadjuvant chemotherapy, Li *et al*. [10] found that the AUC was 0.88, which had a higher predictive value compared with the NAC scheme constructed by DiCenzo *et al*. [4]. Ultrasonographic radiomics profile analysis was also performed on LABC patients and a radiomics nomogram was constructed to evaluate the effectiveness of neoadjuvant chemotherapy, which laid a foundation for clinical personalized diagnosis and treatment. Zhang *et al*. compared the images of breast cancer before and after NAC and found that there were significant differences in the microvessel-based imaging parameters between the two groups, which could be used as indicators to evaluate efficacy [14].

3.5. Research on multimodal ultrasound radiomics

Previous studies have found that in addition to traditional ultrasound imaging, imaging techniques such as shear wave elastography (SWE) and contrast-enhanced acoustic imaging can also improve the efficacy of early diagnosis of breast cancer. Choi *et al*. [6] used SWE, color Doppler flow imaging (CDFI), and traditional ultrasound to perform multi-mode imaging analysis, and clarified the elasticity and number of different types of tumors (NMLs). This helped identify benign and malignant lesions and reduced the diagnostic value of benign NMLs. In addition, SWE and CDFI are more meaningful in the evaluation of NMLs without calcification. Suo *et al*. [7] used a support vector machine (SVM) to classify 158 breast cancer patient's lymph nodes and found that the traditional radiomics method combining ultrasound and elastography could distinguish the presence of a tumor. Kapetas *et al*. [8] performed feature quantification on 124 breast masses using multiple imaging methods, including traditional ultrasound, elastic ultrasound, CDFI, and ultrasound imaging and confirmed that this radiomics method could effectively solve the problem of early detection of breast cancer and reduce the possibility of misdiagnosis [9-12].

4. Challenges in the development of radiomics for breast cancer

Recently, more studies have shown that radiomics technology is of great significance for the accurate diagnosis and treatment of breast cancer. However, the current research on breast cancer imaging is still in the developing stages and there are many problems. Firstly, there is a lack of uniformity of images acquired by instruments used by different manufacturers, resulting in the repeated ability of the models [13]. Second, for the division of the target area, due to the differences in the understanding of the lesion site of the operators, this results in different division criteria for the target area, hence the area drawn is not uniform. Thirdly, among the various radiomics representations, only a few of them can be interpreted and have been widely used in omics analysis. The biological significance of many features is still unclear, which needs further exploration and research. Fourth, the existing breast cancer imaging studies are mainly based on single-center, small-sample retrospective studies, hence there are problems such as imperfect and low accuracy of models. Fifth, breast imaging group research belongs to the multidisciplinary integration of medicine and computer artificial intelligence, which requires the cooperation of imaging, computer image processing, and other fields. The interdisciplinary integration represented by artificial intelligence is an urgent problem that needs to be solved [14].

5. Conclusion

Although the existing ultrasound imaging technology has relatively mature methods and techniques, it still faces many problems, such as the existing image segmentation method that needs to be improved. Accuracy cannot be guaranteed by automatic segmentation. At present, there is no unified standard for the processing of imaged features. There is no unified standard for the extraction of the same or similar reference image data across different hospitals. With the rise of deep learning, imaging diagnostic models built by deep neural networks are expected to further improve the accuracy of imaging diagnosis. However, most of the existing studies used retrospective and single-center research methods, and the results were not comprehensive. Therefore, this project intends to carry out a prospective multicenter clinical study to establish a clinical diagnostic method based on ultrasound imaging. Non-invasive quantitative analysis of traditional ultrasound images using ultrasound imaging technology can provide more accurate, objective, and comprehensive information for the early diagnosis and treatment of breast cancer, to provide new ideas and methods for future diagnosis and treatment.

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Disclosure statement

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