Diagnostic value of artificial intelligence in early-stage lung cancer

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To the Editor: Lung cancer has the highest morbidity and mortality rate among malignancies in the world. The key to improve the 5-year survival rate is early diagnosis and treatment. Artificial intelligence (AI) based on deep learning has the ability of efficient self-optimization, which improves not only the recognition ability of pulmonary nodules, but also helps improve the diagnostic efficiency of early-stage lung cancer.

Patients undergoing pulmonary nodules surgery in Zhongshan Hospital, Fudan University from January 2016 to December 2018 were selected. Inclusion criteria were: (1) Definite surgical pathological diagnosis; (2) Clear and qualified thin-layer chest computed tomography (CT) imaging data within 1 week before operation; (3) Solitary pulmonary nodules (SPN), 5 mm < diameter ≤ 30 mm; (4) Pathological staging of malignant nodules showed tumor in situ (Tis) or IA. The sensitivity and specificity were estimated to be 65% according to clinical experience. Totally, 180 malignant and 180 benign nodules that met the inclusion criteria were selected. In order to balance the confounding factors between the malignant and benign nodules, SPSS 19.0 (SPSS Inc., Chicago, IL, USA) was used to conduct 1:1 propensity score matching (PSM). The matching tolerance was 0.1, and the matching variables were gender and age. The software automatically adopted logistic regression to fit the independent variables and dependent variables, and completed the matching. Among them, benign lung tumors or tumor-like lesions included inflammatory pseudotumor, tuberculous ball, hamartoma, sclerosing hemangioma, fibroma, inflammatory, and infectious diseases. Malignant nodules were classified into adenocarcinoma, squamous cell carcinoma, lymphoepithelial carcinoma and neuroendocrine tumor according to the pathological classification of lung cancer by World Health Organization in 2015.

Thin-layer chest CT image data of 360 nodules were imported into AI analysis system (e-Discover/Lung, V1.0.2, 12-Sigma Technologies, USA). Nodule identification and benign-malignant analysis were carried out automatically. Nodules identified by AI were screened by two senior physicians, false positive results were deleted, and size, density and location of the nodules were reviewed. Two radiologists with more than 10 years of experience in chest CT diagnosis performed the identification of pulmonary nodules and the determination of benign and malignant features. SPSS 19.0 was used for statistical analysis. The measurement data are expressed as mean ± standard deviation. Receiver operating characteristic (ROC) curve was used to determine acceptable malignant probability threshold. Chi-square was carried out for comparison between two groups. There were statistically significant differences when P < 0.05.

Area under ROC curve (AUC) was 0.771 for the diagnosis of early-stage lung cancer by AI. When malignant probability exceeded 85.5% (optimal threshold), the sensitivity and specificity were 62.8%, 77.8%, respectively. Sensitivity and specificity of AI in the diagnosis of lung cancer (62.8%) was lower than that of radiologists (68.3%), while specificity of AI was higher (77.8%) than that of radiologists (62.8%), and the differences were both statistically significant (χ² = 8.48, 6.96; P < 0.05). From evaluation of authenticity (Youden index) and consistency (Kappa value), the diagnostic efficacy of AI and radiologists for early-stage lung cancer was not high (0.41, 0.31) (Table 1). The sensitivity of AI for nodules of different size and density were lower than that of radiologists, and there was also no statistically significant difference (χ² = 0.006, 3.174, 0.194; 0.029, 1.331, 3.669; P > 0.05). The specificities of AI for nodules of different size and density were higher than those of radiologists, and the differences in groups of 5.0 to 10.0 mm and 10.1 to 20.0 mm were statistically significant (χ² = 4.916, 5.733; P < 0.05). There was no significant difference between groups with
20.1 to 30.0 mm nodules and nodules with different densities ($P > 0.05$). Compared with single diagnosis by AI or radiologists, the sensitivity of combined diagnosis was significantly improved (83.3%) ($\chi^2 = 60.72$, 76.05; $P < 0.05$), while specificity decreased (52.8%) ($\chi^2 = 57.48$, 119.28; $P < 0.05$) (Table 1).

The urgent clinical needs promote the development of AI in the detection of pulmonary nodules and the judgment of benign and malignant.[1] Deep learning is a branch of AI, which improves diagnostic accuracy by building a learning model and carrying out repeated and extensive training. Convolutional neural network (CNN) is the most commonly used image classification and processing model in deep learning.

The sensitivity and accuracy of classifying pulmonary nodules by CNN is better than that of radiologists.[2-4] In this study, the AUC was plotted by samples, and threshold of malignant probability was 85.5% when both sensitivity and specificity were considered. However, large-scale clinical validation was lacking. Sensitivity, specificity and accuracy of AI in the diagnosis of early-stage lung cancer were 62.8%, 77.8%, and 70.3%, respectively, which were lower than those reported in the literature, which may be related to the quality of the original database used for training AI.

In conclusion, AI based on deep learning has a better specificity in the diagnosis of early-stage lung cancer, while its sensitivity is not as high as that of radiologists. The combination of the two can obtain higher sensitivity, which has certain value in early diagnosis of lung cancer.

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### Conflicts of interest

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