**Figure supplementary**

**Figure S1**



**Figure S1. Datasets image example and image processing.** A, shows one original slice of CT series including the thymoma region; B, illustrates the annotated image using the related image mask; C, is the segmented thymoma region; D, is the thymoma region that excludes the irrelevant surroundings, used for radiomics feature extraction and deep learning model.

**Figure S2**

**Figure S2. The parameter tuning in LASSO method.** Figure A shows the relevance affected by different regularization coefficient alpha, and features with non-zero coefficients can be identified as relevant features; (B) By using five-fold cross validation in LASSO, the coefficients alpha can be chosen when Mean Square Error (MSE) has minimum value. Then, relevant features can be selected based on alpha.

**Figure S3**



**Figure S3. The data augmentation using random cropping.** The left is the original segmented thymoma ROI, and the right is random generated training samples which are illustrated as cubes. During training, the thymoma ROI can be placed in any position within the cube to increase data variability.

**Figure S4**



**Figure S4. The heatmap of radiomics feature correlation analysis.** The heatmap shows the correlation coefficient ranging from -1 to 1 for the extracted 16 features. It can be seen that the majority of these features have lower correlation coefficients, meaning that redundant features with higher coefficients have been removed from the original extracted features. The correlation between features was analyzed using Pearson method.

**Figure S5**



**Figure S5. The clinical flow chart for preoperative screening of MG in thymoma patients.** This clinical flow chart was based on the information from our 3D-DenseNet-DL based multi-model, clinical symptoms and serum AChR antibody. Thymoma patients suspected of having MG should be further diagnosed by a neurologist using standard diagnostic criteria, followed by necessary clinical management and preoperative risk assessment of the disease.

**Table supplementary**

Table S1: The structure of the 3D-DenseNet.

|  |  |  |
| --- | --- | --- |
| **Layers** | **Output Size (pixels)** | **Operation** |
| Conv | 80 × 80 × 32 | 7 × 7 × 7 Conv, Stride 2 |
| Pooling | 40 × 40 × 16 | 3 × 3 × 3 Max Pool, Stride 2 |
| Dense Block 1 | 40 × 40 × 16 | 6 × (3 × 3 × 3 BottleNeck-Conv) |
| TL-Conv 1 | 40 × 40 × 16 | 1 × 1 × 1 Conv |
| TL-Pooling 1 | 20 × 20 × 8 | 2 × 2 × 2 Average Pool, Stride 2 |
| Dense Block 2 | 20 × 20 × 8 | 12 × (3 × 3 × 3 BottleNeck-Conv) |
| TL-Conv 2 | 20 × 20 × 8 | 1 × 1 × 1 Conv |
| TL-Pooling 2 | 10 × 10 × 4 | 2 × 2 × 2 Average Pool, Stride 2 |
| Dense Block 3 | 10 × 10 × 4 | 24 × (3 × 3 × 3 BottleNeck-Conv)  36 × (3 × 3 × 3 BottleNeck-Conv)  32 × (3 × 3 × 3 BottleNeck-Conv)  48 × (3 × 3 × 3 BottleNeck-Conv) |
| TL-Conv 3 | 10 × 10 × 4 | 2 × 2 × 2 Average Pool, Stride 2 |
| TL-Pooling 3 | 5 × 5 × 2 |  |
| Dense Block 4 | 5 × 5 × 2 | 16 × (3 × 3 × 3 BottleNeck-Conv)  24 × (3 × 3 × 3 BottleNeck-Conv)  32 × (3 × 3 × 3 BottleNeck-Conv)  32 × (3 × 3 × 3 BottleNeck-Conv) |
| Pooling | 1 × 1 × 1 | 3 × 3 × 4 Global Average Pooling |
| FC Layer |  | Fully Connected Layer, Softmax |

Note: Conv, convolutional operation, by default including batch normalization and activation layer; BottleNeck-Conv, layer that includes 1×1×1 convolution before regular convolutions for parameters reduction; TL-Conv or TL-Pooling, transition layers to connect dense blocks.

Table S2. 16 selected radiomic features in the final analysis.

|  |  |
| --- | --- |
| **Feature Name** | **Descriptions** |
| Sphericity | Roundness of the shape of ROI. |
| LeastAxisLength | The smallest axis length of the ROI-enclosing ellipsoid. |
| Flatness | The relationship between the largest and smallest principal component. |
| square\_glcm\_Correlation | Linear dependency of gray level values to voxels. |
| log-sigma-3-0-mm-3D\_firstorder\_Maximum | The maximum gray level intensity within the ROI. |
| wavelet-LHL\_glcm\_Correlation |  |
| wavelet-LHH\_glszm\_SmallAreaLowGrayLevelEmphasis | The proportion in the image of the joint distribution of smaller size zones with lower gray-level values. |
| wavelet-LLH\_firstorder\_Skewness | The asymmetry of the distribution of values about the Mean value. |
| wavelet-HLH\_glszm\_LargeAreaHighGrayLevelEmphasis | the proportion in the image of the joint distribution of larger size zones with higher gray-level values. |
| wavelet-HHH\_gldm\_LowGrayLevelEmphasis | The distribution of low gray-level values, with a higher value indicating a greater concentration of low gray-level values in the image. |
| wavelet-HHH\_glrlm\_LowGrayLevelRunEmphasis |  |
| wavelet-HHH\_glrlm\_LongRunLowGrayLevelEmphasis | Joint distribution of long run lengths with lower gray-level values. |
| wavelet-HHH\_glszm\_SmallAreaEmphasis | Distribution of small size zones, with a greater value indicative of more smaller size zones and more fine textures. |
| wavelet-HHL\_glrlm\_LowGrayLevelRunEmphasis |  |
| wavelet-LLL\_glcm\_Imc2 | The correlation between several probability distributions. |
| wavelet-LLL\_gldm\_DependenceNonUniformityNormalized | The similarity of gray-level intensity values in the image |

Note: prefix of “square”, “log” and “wavelet-” represent for different image filters.

Table S3. The prediction metrics of the deep learning results from training and five-fold cross-validation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **AUC** | **Accuracy** | **Precision** | **Sensitivity** | **Specificity** |
| Training |  |  |  |  |  |
| Fold 0 | 0.879 | 0.812 | 0.750 | 0.919 | 0.712 |
| Fold 1 | 0.886 | 0.867 | 0.795 | 0.984 | 0.754 |
| Fold 2 | 0.989 | 0.930 | 0.877 | 0.990 | 0.859 |
| Fold 3 | 0.896 | 0.844 | 0.772 | 0.968 | 0.723 |
| Fold 4 | 0.811 | 0.766 | 0.739 | 0.810 | 0.723 |
| mean | 0.892 | 0.844 | 0.787 | 0.936 | 0.754 |
| Validation |  |  |  |  |  |
| Fold 0 | 0.756 | 0.727 | 0.714 | 0.667 | 0.778 |
| Fold 1 | 0.726 | 0.727 | 0.650 | 0.867 | 0.611 |
| Fold 2 | 0.693 | 0.697 | 0.609 | 0.933 | 0.500 |
| Fold 3 | 0.835 | 0.812 | 0.765 | 0.867 | 0.765 |
| Fold 4 | 0.663 | 0.656 | 0.643 | 0.600 | 0.706 |
| mean | 0.734 | 0.724 | 0.676 | 0.787 | 0.672 |