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## Wenlin index of pectus excavatum

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### Abstract

Pectus excavatum is a common thoracic deformity. There are many clinical indicators to evaluate its severity, among which Haller index is the most commonly used one. However, this index has many defects. In order to eliminate these defects, we designed a new index, namely Wenlin index. This index is the normalized depression depth, which is an ideal value because it can directly reflect the degree of depression. We believe that if this value is used together with Haller index, the severity of pectus excavatum can be evaluated more comprehensively.

**Keywords:** Wenlin index, Haller index, pectus excavatum

### Introduction

Pectus excavatum is a common thoracic deformity [1]. Its harm includes two aspects, one is physiological harm, and the other is psychological harm. Both aspects may affect the health and life of patients, so pectus excavatum needs treatment [2-4]. Before the treatment, the diagnosis and severity of the deformity should be made clear. The diagnosis can be directly obtained according to the appearance of the thorax, but the severity needs to be judged by some indicators. In the past, many indicators have been used in the clinic, and the Haller index is the most commonly used [5-10]. This index is easy to obtain and has good reference value. However, it also has obvious defects. In some special cases, this index cannot reflect the true severity of pectus excavatum. Our department is the first and only independent chest wall surgery in China [11, 12]. Our main work is to complete various chest wall operations. In our work, pectus excavatum surgery accounted for the majority. Through the observation of a large number of patients, we found a more effective indicator can be obtained through other way to judge the severity of pectus excavatum. In order to distinguish this indicator from other indicators, we named it Wenlin index. We have used this index in the clinic for a long time and achieved satisfactory results.

### Acquisition and calculation of Wenlin index

The data are obtained mainly from the cross-sectional plane of chest wall CT (Fig 1). Two basic data need to be obtained, A and B. A horizontal line is made on the highest plane of the anterior chest wall at first, and then a vertical line is made from the anterior median of the spine to the horizontal line. After the two straight lines are completed, the data can be measured. The first data is the length a of the vertical line, which is represented by A, and the second data is the distance from the deepest part of the depression to the horizontal line, that is, the depth of the depression, which is represented by B. After the values of A and B are measured, the Wenlin index is calculated by the following formula:

$$\text{Wenlin index} = B / A$$

### Judgment of the severity of pectus excavatum

In order to judge the severity of pectus excavatum, we designed an extremely simple method. On the cross-sectional plane of CT, the vertical line is divided into three equal parts, and the severity of pectus excavatum is determined according to the position of the bottom of the depression (Fig 2). Those in the upper third are mild, those in the middle third are moderate, those in the lower third are severe, and those in excess of the lower third are extremely severe.

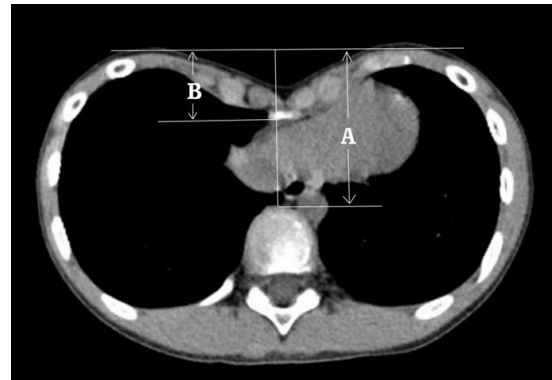
Since the three equal parts respectively account for one third of the total length, the corresponding values of the two dividing points are 0.33 and 0.67 respectively. By comparing these two values with the Wenlin index, the judgment of the severity of pectus excavatum can be obtained. That is, when the Wenlin index is less than 0.33, it is mild; greater than 0.33 and less than 0.67, it is moderate; greater than 0.67, it is severe; and greater than 1, it is extremely severe.

### Discussion

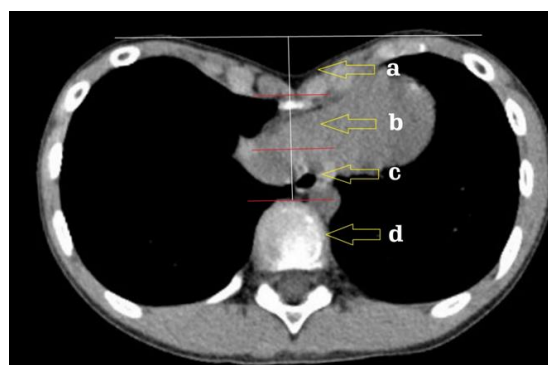
The judgment of the severity of pectus excavatum is an important basis for recognizing and treatment. In the past, many indicators were used to judge the severity [5-10]. These indicators describe the severity of pectus excavatum from different angles, but each indicator is not comprehensive enough and there are certain problems. Among these indicators, Haller index is used most [5]. This index is considered to be a relatively objective indicator. However, in many cases, this index also has disadvantages. For example, in the two cases shown in Fig. 3, the depth of the depression is different, but the value of the Haller index is exactly the same. It is clear that the Haller index cannot accurately describe the severity of pectus excavatum in such cases (Fig 3). In essence, Haller index describes the relative distance between the bottom of the depression and the front of the spine. In fact, such a value has no essential relationship with the degree of depression. The most direct value of the depression degree is the depth of the depression. Obviously, the Haller index cannot reveal the depth.

The method of reflecting the depression depth is very simple and can be directly measured. However, because the depth of different cases is different, the measured value must be processed if it is to have practical significance, which requires a standardized process. Our practice is to use the anterior posterior distance of the normal mediastinum as a reference for standardization, that is, the ratio of the actual depth and this distance. We call this ratio Wenlin index. It can be seen from the measurement and calculation process of this index that the essence of Wenlin index is the relative depth of pectus excavatum depression. Since it has been standardized, it accurately reflects the severity of the depression and makes it possible to compare the depression degrees of different patients. Compared with Haller index, Wenlin index has the following advantages: (1) Directly evaluating the depth of the depression can more accurately reflect the severity of pectus excavatum; (2) The severity of pectus excavatum can be described more intuitively. The severity of pectus excavatum is divided into four

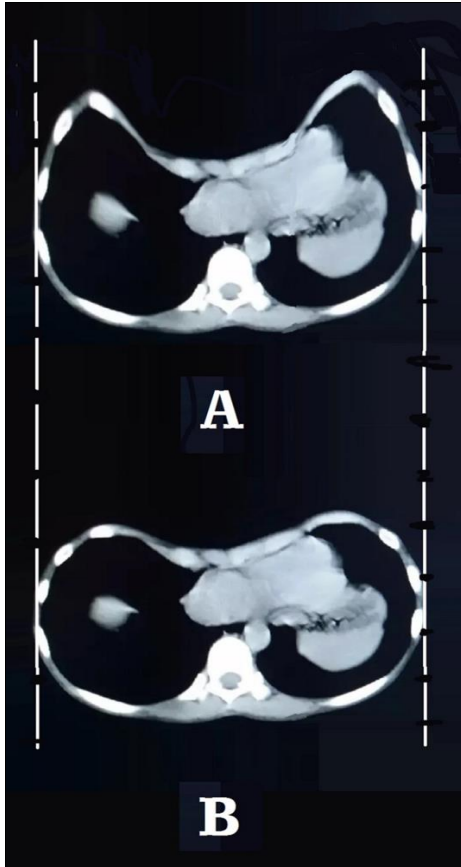
levels, and the difference of each level is  $1/3$ , i.e. 0.33. The magnitude of Wenlin index can directly reflect the severity; (3) The depression severity can be described more comprehensively. Although Haller index can be used to describe the severity of the depression, for some extremely serious depressions, such as the deformity that the bottom of the depression exceeds the front of the spine, Haller index can only use negative values to indicate the severity. Such a numerical value is neither scientific nor practical. On the contrary, the Wenlin index can describe this extremely serious lesion precisely. The Wenlin index of this deformity will be greater than 1; (4) It does not significantly increase the difficulty of numerical measurement. Haller index is measured from the cross-sectional plane of CT, and Wenlin index is also from this cross-sectional plane. Although the measurement steps of Wenlin index are increased, the steps are very simple and will not significantly increase the difficulty; (5) The Wenlin index can be obtained in a more flexible way. For the same patient, since the depth values observed in different sections are basically the same, the Wenlin index can be obtained through different routes. The first route is the sagittal plane of CT (Fig 4), and the second route is the lateral plane of X-ray examination (Fig 5). The measurement methods of the two routes are almost the same as those in the CT cross-sectional plane, and the values are also basically the same. In particular, it should be emphasized that since the Wenlin index can be obtained by X-ray examination, CT examination is no longer necessary. This will undoubtedly greatly simplify the process of preoperative examination.



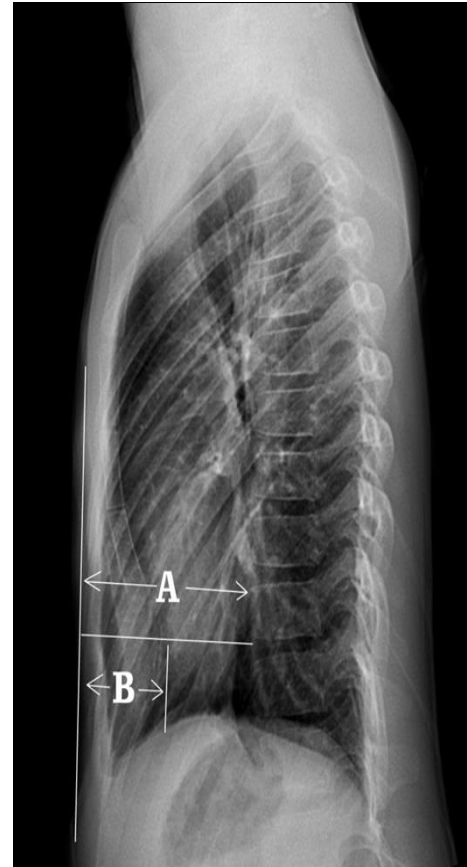
**Fig 1:** Measurement of Wenlin index on CT cross section plane. A, Depth of depression; B, Vertical width of the mediastinum.



**Fig 2:** Judgment of the severity of pectus excavatum. a. Mild; b. Moderate; c. Severe; d. extremely severe.



**Fig 3:** Two cases of pectus excavatum with different degrees of depression. The Haller index is completely the same, but the Wenlin index is different.



**Fig 5:** Measurement of Wenlin index on lateral plane of X-ray. A, Depth of depression; B, Vertical width of the mediastinum



**Fig 4:** Measurement of Wenlin index on CT sagittal plane. A, Depth of depression; B, Vertical width of the mediastinum.

**Conclusion**

In conclusion, Wenlin index is an ideal index to evaluate the severity of pectus excavatum depression. This value can be easily obtained with CT images. If there is only X-ray examination, the approximate Wenlin index can also be obtained. Therefore, Wenlin index is a simple and practical index to evaluate the severity of pectus excavatum. However, since any indicator has its own shortcomings, in the process of use, the defects of Wenlin index will be gradually discovered. Our suggestion is that this index can be used in combination with Haller index, which may make a more comprehensive evaluation of the severity of pectus excavatum.

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