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## Wenlin procedure for treatment of pectus carinatum

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### Abstract

Pectus carinatum is a common thoracic deformity, and its treatment has a long history. The early operation was open operation. With the emergence of the concept of minimally invasive surgery in clinical practice, minimally invasive surgery of pectus carinatum has gradually become the mainstream in its treatment. The earliest minimally invasive operation was Abramson procedure. This kind of operation has certain effect, but it also has many disadvantages. In order to eliminate its disadvantages, we designed a new operation, Wenlin procedure. In essence, this operation is a template plastic surgery. Because of the special design, it has obvious advantages. So far, this operation has been widely used in China. Clinical experience shows that this operation is safe, simple and practical. However, like all other operations, this operation also has defects. In the future use process, its defects need to be continuously discovered and improved.

**Keywords:** Wenlin procedure, pectus carinatum, operation

### Introduction

Pectus carinatum is a common thoracic deformity [1]. Its incidence is only second to pectus excavatum. It is mainly manifested as protrusion of anterior chest wall [1-3]. There are two aspects of the influence of pectus carinatum on patient: one is psychological influence, and the other is physiological influence [1, 4, 5]. Psychological influence mainly comes from abnormal appearance. Patients may have low self-esteem, autism and even more serious psychological problems due to the deformed appearance. The Physiological influence mainly comes from the abnormal heart and lung function caused by the deformed chest wall structures. Since the chest wall of the pectus carinatum is mainly characterized by protrusion, the compression on the heart and lungs basically does not exist, and the physiological influence is not caused by the compression of the chest wall, but secondary to psychological influence in most cases. Therefore, the main influence of patients with pectus carinatum is psychological one. Most patients worry about the appearance of the chest wall and desire surgical treatment.

Pectus carinatum surgery has a history of many years. The operations in the early years were open operations [2, 3]. The main method is to cut or excise the local bone structures of the lesion, and then adjust the shape of the relevant structures to eliminate the deformity and obtain a satisfactory appearance of the chest wall. In the early years, there were many specific types of operation, but basically all had similar principles, and all belonged to the category of destructive plastic surgery [4, 5]. The biggest feature of these operations is that they can be operated under direct vision, so the operability of the operation is better. However, due to the long incision and wide range of operation field, the injury is great and the scar after operation is obvious. These factors are unfavorable to the patient's recovery after operation and also affect the aesthetics.

With the introduction of the concept of minimally invasive surgery into the clinic, the Nuss procedure has received great attention, which is a minimally invasive operation for the treatment of pectus excavatum [6]. Influenced by this surgical concept, some people tried to treat pectus carinatum with similar methods. Abramson was the first surgeon to use this method. In 2005, he reported the minimally invasive surgical method for the treatment of pectus carinatum [7], thus opening a new era of pectus carinatum treatment.

Abramson procedure is to use the bar of Nuss procedure to correct the pectus carinatum (Fig 1, 2A). In this procedure, the steel bar of Nuss procedure is placed on the surface of the anterior chest wall. After the chest wall is pressed by the bar, its two ends are fixed on the ribs of the lateral chest wall.

During this process, the bar is not directly fixed, but indirectly fixed by means of a short fixing plate. Abramson procedure utilizes the steel plate and the method of Nuss procedure for reference [6], therefore, some people call it anti-Nuss operation [8]. This appellation has certain rationality. However, if the details of the operation is analyzed, the procedure is not completely opposite to that of Nuss procedure. To be precise, it's just a connection. If the two procedures are forcibly linked, it will adversely affect the design and operation.

In the process of designing Abramson procedure, the author was obviously influenced by this concept [7], therefore, the adverse effect is particularly obvious in this procedure: (1) the disadvantages of using Nuss procedure fixation plate. Nuss procedure steel bar has a good effect in the correction of pectus carinatum, but the use of fixation plate has many problems [6]. First, the fixation plate has a large volume, thus its use requires a large incision (Fig 2A); Second, the fixation plate will protrude from the body surface, not only affect the wound healing, but also cause local discomfort after operation; Third, the use of fixation plate makes the fixation between the steel bar and the rib only in an indirect way but direct way, which will affect the results of fixation; Fourth, using fixation plate makes the stress of the steel bar only located at its end, but the middle part of the bar cannot be additionally fixed. This kind of fixation completely determines the nature of Abramson procedure to be mechanical external force plastic surgery, which is not the most ideal operation; (2) adverse effects of Nuss procedure concept. Nuss procedure is not a perfect operation, and its design has many disadvantages. Abramson procedure directly borrowed from Nuss procedure and applied its concept to the operation, which will undoubtedly inherit the disadvantages of Nuss procedure.

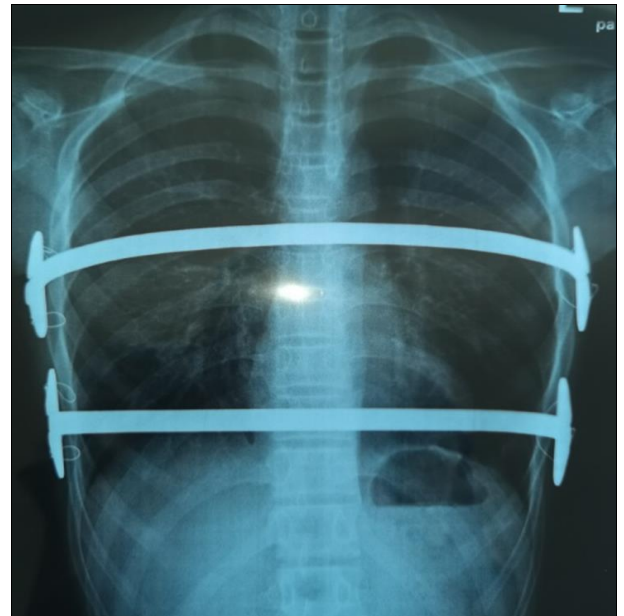
When Abramson procedure appeared in the clinic, it has been widely concerned because it has completely changed the treatment concept of pectus carinatum. However, due to the defects of the operation itself, its promotion is limited. Compared with Nuss procedure of pectus excavatum, the situation of Abramson procedure is obviously less optimistic. The reason is mainly related to its inherent disadvantages. These drawbacks have greatly affected the effect of pectus carinatum surgery, so many doctors have no confidence to carry out the operation.

Our department is the first independent chest wall surgery department in China and the largest thoracic deformity correction center [4, 5]. Our main work is to carry out the operation of various chest wall diseases, and the operation of chest wall deformity is our main work. Among all kinds of thoracic deformities, pectus carinatum accounts for a large proportion. In the early stage, we used open surgery to treat pectus carinatum. After Abramson procedure appeared, we also used it. However, we soon found its disadvantages, then we made great improvement on it, and finally designed a new operation, namely Wenlin procedure [1].

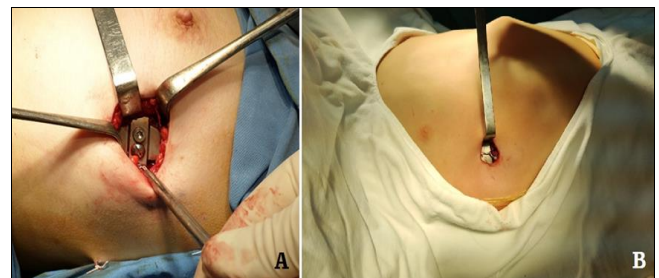
Wenlin procedure is a new operation designed on the basis of Abramson procedure. In the operation, the placement of the steel bar is basically the same as that of Abramson procedure. The biggest difference is that the fixation plate is removed and the two ends of the steel bar are directly fixed on the ribs (Fig 2). Additionally, the fixation position is not only the end of the steel bar, but also other parts, which are located on different ribs (Fig 3). The advantages of this method are: (1) the steel bar is directly fixed on the rib, and the fixation effect is more accurate; (2) the fixed parts are located in different ribs and not on the same plane, which is conducive to dispersing stress and not easy

to cause fracture of steel wire or ribs; (3) since the fixation plate is no longer used, the space in the incision is saved, which not only makes the surgical field cleaner, but also make it more helpful to shortening the incision length; (4) after the fixation plate is no longer used, the number of foreign bodies in the incision will be reduced, which will be effective to the healing of the incision; (5) since there is no fixation plate protruding from the body surface after the operation, the patient will feel more comfortable; (6) since the fixing position may be located inside the end of the steel bar, it can lift the local depression at the same time, which is more useful to the correction of deformity; (7) the operation adopts the principle of template plastic surgery, and the shaping effect is more accurate and satisfactory.

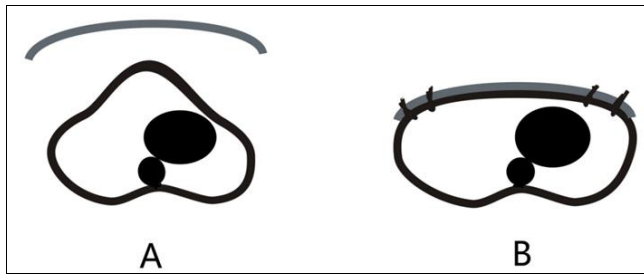
The above advantages are very significant, which makes Wenlin procedure significantly superior to Abramson procedure. In addition to such advantages, Wenlin procedure has other advantages: (1) simplicity. The most difficult operation in pectus carinatum surgery is the fixation of the bar. In order to reduce the difficulty of operation, we designed an extremely simple and convenient technique, namely Wang technique. The application of this technique greatly reduces the difficulty of the whole operation; (2) safety. All operations of Wenlin procedure are limited to the chest wall and do not damage the internal structures of the chest, so the safety index is significantly increased.



**Fig 1:** X-ray picture after Abramson procedure. The fixation method of steel bar refers to the method of Nuss procedure, and the fixation plate is used for indirect fixation.



**Fig 2:** Comparison of bar fixation methods between Abramson procedure and Wenlin procedure. A, Abramson procedure's fixation method requires the use of a special fixation plate; B, In Wenlin procedure, the steel bar is directly fixed to the rib by steel wires.



**Fig 3:** Schematic diagram of Wenlin procedure. This kind of operation can not only compress the protrusion, but also lift the depression of the side chest wall, so it is a typical template plastic surgery. This is exactly the difference between Abramson procedure and Abramson procedure in operation principle.

**Obviously, Wenlin procedure has many advantages. However, as a special operation, it is necessary to pay attention to some technical points. These points include the following**

1. The steel bar should have a proper length. Wenlin procedure is a kind of template plastic surgery, which requires a suitable template for operation. The template of Wenlin procedure is the steel bar, and the shape of the bar should be the shape of the normal thoracic appearance. Such a shape must have multiple decisive elements, but the first of which is length. If the length of steel bar is insufficient or too long, it cannot play an effective role. Generally speaking, the length of the steel bar should be beyond the axillary frontline on both sides. The specific length should be determined according to the characteristics of deformity.
2. The steel bar should have proper radian. The steel bar used in Wenlin procedure is a template, so its radian is very important. Considering the hardness of bone and the elasticity of steel bar itself, the influence of stress must be considered in the design of steel bar shape. The radian should not be too large, but it also should not be too small.
3. The number of steel bars should be appropriate. The factors that determine the number of steel bar are mainly as follows: First, the range of deformity. The wider the range, the more steel bars are required; Second, the degree of deformity. The more severe the deformity, the more steel bars are needed; Third, the hardness of bones. The harder the bone, the more steel bars are needed.
4. The position of the steel bars should be reasonable. The position of the steel bar affect the plastic effect directly, meanwhile, it also affect the stress distribution. Therefore, the position of the steel bar must be designed according to the specific needs during the operation, which is one of the key factors for the success of the operation.
5. The fixation of the steel bar should be reliable. In Wenlin procedure, the fixation of steel bar is an important operation. Because the incision is generally small, it is difficult to obtain good results if the method is inappropriate. In order to make the fixation effective and simple, we designed a very special fixation method, Wang technique. This technique is used in many deformity operations. A great deal of clinical experience shows that this technique is a very ideal fixation technique.
6. The sequence of surgical procedures should be carefully designed. There are generally only two incisions in Wenlin procedure, and both are very short. When all operations are completed through these two short and small incisions, if there is no good order, the operating field will be very chaotic, which will bring great inconvenience to the

operation. In order to avoid this problem, we designed a complete set of operation procedures to make the operation orderly and ensure the smooth operation.

In general, Wenlin procedure is not too difficult. As long as the above technical points are properly handled, good results can generally be obtained.

After Wenlin procedure was designed, we routinely used it in all pectus carinatum operations and achieved satisfactory results. In addition to using this operation in our own hospital, we have also assisted hundreds of hospitals in China to carry out this operation. At present, the application of this kind of operation in China has reached nearly 1000. Due to the reasonable design, convenient operation and satisfactory effect, this operation has been widely recognized. At present, a large number of surgeons have carried out this operation and achieved good results.

In addition to being used in pectus carinatum surgery, we also found that Wenlin procedure can be used for all protrusion deformities of the anterior chest wall. For example, for Wenlin chest [9, 10], barrel chest [11, 12], asphyxiating thoracic dystrophy [13-15], etc, this procedure can be used to eliminate the deformities and obtain satisfactory results.

However, like all other operations, Wenlin procedure can also has defects. In the process of treating pectus carinatum, there will also be some complications. In addition, this operation is not a panacea. When the convex deformity is very serious, it is difficult to obtain perfect results by using this operation alone. At this time, it is often necessary to use other operations in combination to completely eliminate the deformity.

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