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Progress in chest wall surgery

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Abstract

The concept of chest wall surgery first appeared in 2008. After more than ten years of development, a large number of doctors around the world have made great progress, thus making the concept of chest wall surgery widely spread and appear in clinical practice as an independent specialty.

Keywords: Chest wall surgery

Introduction

Chest wall surgery is a new concept, which was first proposed by us in 2008. The purpose of my work was to attract the attention of thoracic surgeons to the chest wall diseases. In the following years, we have completed lots of works around this concept. On May 9, 2018, we established the world's first independent chest wall surgery department in our hospital, which made chest wall surgery from a concept to a reality, and finally became a new member of clinical surgery^[1, 2].

Chest wall disease mainly refer to the sum of various diseases occurring on the chest wall. Specifically, it includes five basic diseases, namely deformity, infection, tumor, defect and trauma^[1, 2]. The incidence of the five diseases is high and should be taken seriously. However, with the prevalence of the concept of minimally invasive surgery in recent years, thoracoscopic surgery has become a synonym for thoracic surgery. Thoracoscopic surgery is a technique for the treatment of intrathoracic diseases. When such technique prevails, the treatment of non intrathoracic diseases, that is, chest wall diseases, will inevitably be ignored. As a result, many thoracic surgeons are unlikely to be concerned about chest wall disease, and they will focus almost all their attention on the treatment of intrathoracic diseases^[1, 2]. This reality has caused the polarization of the treatment of chest diseases and formed a vicious circle. More and more surgeons only operate on intrathoracic diseases, while more and more chest wall diseases cannot be treated. Although this reality reveals the serious lag in the treatment of chest wall diseases, it also highlights a huge development opportunity. It was this opportunity that prompted us to put forward the concept of chest wall surgery and finally built the first chest wall surgery department. After that, we have worked closely around five diseases and accumulated rich experience. While completing our own hospital work, we also helped a large number of hospitals to carry out the clinical work of chest wall surgery in China, and finally established the China Chest Wall Surgery Alliance^[1, 2]. With the development of these works, the concept of chest wall surgery has been gradually spread, and more and more thoracic surgeons have joined in the work of chest wall surgery.

While carrying out chest wall surgery in China, we also promoted this concept internationally. As chest wall surgery is a recognized development trend, many international peers have gradually participated in this work and achieved good results. Reviewing the development of chest wall surgery in recent years, the achievements can be summarized as follows:

1. The theoretical system of chest wall surgery is gradually improved. The concept of chest wall surgery was first proposed as a sub specialty of thoracic surgery. In the later development process, its own particularity emerged, which made it gradually exceed the scope of traditional thoracic surgery and become a new specialty. This specialty can be regarded as the orthopedics or plastic surgery of chest wall, or even the cosmetic surgery of the chest wall. These contents endow chest wall surgery with more new connotation. Specific to the scope of chest wall diseases, it is no longer limited to traditional thoracic surgery diseases, and even includes more other diseases. In terms of surgical treatment, the nature of chest wall surgery has been clarified.

It includes two attributes: treatment and shaping. Treatment mainly refers to the removal of lesions, but shaping has different meanings, which includes two basic technologies: plastic surgery and reconstruction. In general, after several years of development, chest wall surgery has not only been a simple clinical practice, but has gradually become a complete theoretical system. This has laid a solid theoretical foundation for the future development of the specialty^[1, 2].

2. Progress in the treatment of chest wall deformity. Chest wall deformity, or thoracic deformity, is the most common disease in chest wall surgery, so it has always been the focus of chest wall surgery research. At the beginning of chest wall surgery, the concept of thoracic deformity was defined. The broad sense includes the deformity of bone structures and all other structures, but the narrow sense is only the deformity of bone structures. The common feature of all deformities is the appearance of abnormal shape of chest wall. This is the structural basis for the existence of deformities. There were four classic types of chest deformities, namely pectus excavatum^[3, 4], pectus carinatum^[5, 6], flat chest^[7] and barrel chest^[8, 9]. With the deepening of understanding, new deformities are gradually recognized and named. The renamed deformities include: groove chest^[10], saddle chest^[11], lateral chest wall depression^[12], Wenlin chest^[13, 14], flat pectus carinatum and rib arch deformity^[15]. In the past, these deformities were either considered as other diseases or were neglected completely. Because of the distinctive characteristics, it is necessary to make new names so as to better understand and treat them. In addition to these special deformities, some special concepts have been proposed, such as malignant pectus excavatum, acute angle deformity, etc., which are the key descriptions of some special deformities.

After the appearance of the new name, there are more and more types of thoracic deformities. In order to facilitate the development of clinical work, all deformities are divided into two categories^[16]. Class I is depression deformity and Class II is protrusion deformity. This division makes the internal connection of different deformities fully recognized, which is not only conducive to better understanding of deformities, but also conducive to the treatment of them.

In early years, the treatment of thoracic deformity was all open surgery, which had obvious disadvantages, so it gradually withdrew from clinical practice^[17]. After entering the era of minimally invasive surgery, Nuss procedure has become a representative operation^[18]. Although this procedure is still the main operation for pectus excavatum, more and more new operations have gradually entered clinic and achieved good results. In general, in addition to Nuss procedure, Wang procedure^[3, 4, 19, 20] and Wung procedure^[21] are also available for depression deformity. Wang procedure is a new operation different from Nuss procedure. Although Wung procedure is an improved Nuss procedure, the details are almost completely different, and it is also a new operation. There are two kinds of surgery for protrusion deformity, one is Abramson procedure and the other is Wenlin procedure^[5, 6, 22]. Although the two procedures are somewhat similar, the natures of them are completely different. Essentially, the operations for various deformities can be divided into three categories, namely destructive plastic surgery, mechanical external force plastic surgery, and template plastic surgery^[1, 2, 23, 24]. The open surgeries, such as Ravitch procedure, are the typical destructive plastic surgeries. Nuss procedure and Abramson procedure^[25] are typical mechanical external force plastic surgeries, while Wang procedure and Wenlin procedure are template plastic

surgeries. Template plastic surgery is a more advanced surgical method.

Pectus excavatum is the most common thoracic deformity. Although Nuss procedure has always been popular, its drawbacks cannot be eliminated completely. In order to improve the clinical effect, many improved surgical methods have been used in clinic. However, because some disadvantages cannot be eliminated fundamentally, this operation is not perfect. Wang procedure is not a modified Nuss procedure, but a brand-new operation^[19]. Because the position of the steel bar is completely different from that of Nuss procedure, the related disadvantages can be eliminated.

So far, pectus excavatum surgery is the most widely performed surgery, nevertheless, under the influence of various reasons, the current surgery of pectus excavatum is not ideal. Most thoracic surgery centers cannot even perform simple pectus excavatum surgery, let alone complicated pectus excavatum surgery. In addition, due to lack of sufficient experience, there are always failures in Nuss procedures, and the reoperation of such failed cases is challenging. Nuss procedure is not only risky, but also very difficult when it is used again. In contrast, Wang procedure or Wung procedure can reduce the difficulty and risk in the reoperation. Moreover, if Wenlin procedure is used together, better results can be obtained^[26]. The pectus excavatum operation after cardiac surgery is similar to this operation and can be treated in a similar way.

Pectus carinatum is the most common protrusion deformity. Due to the complexity of the operation, its treatment is far inferior to pectus excavatum. Early pectus carinatum surgery was also open surgery. After Nuss procedure appeared, some people associated it with the opposite operation, so there was the so-called anti-Nuss procedure, which was mainly represented by the Abramson procedure. Although this procedure employs new technology, it still uses a full set of Nuss surgical main steel bars and fixation plates, which will undoubtedly limit the design of the operation. In this kind of operation, the use of fixation plates makes the main steel bar can only be fixed on the rib indirectly. This fixation method not only increases the difficulty of surgery, but also affects the effect. Wenlin procedure is similar to Abramson procedure on the surface, but in fact it is completely different. Because Wenlin procedure uses a special method to directly fix the steel bar with ribs, it is very simple and easy to operate, and finally becomes the perfect choice for treating pectus carinatum^[5, 6, 22].

Flat chest is also a common thoracic deformity. Nuss procedure was used by some authors for this deformity in the past, but this procedure is easy to fail. According to the new concept, in order to complete the operation, the operation details must be designed reasonably^[7].

Barrel chest is another common thoracic deformity, but in the past, the understanding of this deformity mainly came from the elderly patients with chronic lung diseases, who often had barrel chest. This kind of deformity is essentially a secondary lesion. On the premise that the primary disease cannot be eliminated, this deformity cannot be treated. Some young and middle-aged patients also have barrel chest. Their deformities are primary lesions, which have no connection with chronic lung disease. These patients are often troubled by the appearance of the chest wall and eager for treatment. Since barrel chest can be regarded as protrusion deformity of anterior chest wall, Wenlin procedure can be used for correction. We have done a lot of barrel chest surgery with this technology, and achieved satisfactory results^[8, 9]. So far, our department is the only center in the world to carry out surgery for this deformity.

Wenlin chest is a special deformity we named ^[13, 14]. In the past, this deformity was regarded as a kind of pectus carinatum, but because of the special structural changes, we think it is necessary to treat it as an independent deformity. In the past, there were different names for this deformity, which include pigeon breast ^[27], Pouter pigeon breast ^[28], currarino-Silverman syndrome ^[29-32], Chondromanubrial deformity ^[32], pectus Arcuatum ^[33-36] and others. Some authors even regarded it as a compound deformity consisting of pectus excavatum and pectus carinatum. All These names are different, but the revealed features are the same. The main lesion is located in the sternum. The sternal angle is thickened and bulged, causing the costal cartilage and ribs connected to it on both sides to be protrusive accordingly. A depression is formed at the lower part, and the bottom of the depression is the sternal body. The whole sternum is in "S" shape ^[13, 14]. This kind of deformity is not a single deformity, but a complex one with both protrusion and depression. However, due to the overall thickening of the sternum, it is almost impossible to use the ordinary sandwich surgery to complete the treatment. Our method is Wenlin procedure combined with Wung procedure or Wang procedure, and the prerequisite for successful operation is to perform pre-shaping first, which is the key to the success of the operation.

Wenlin chest is considered to be a very rare deformity, and clinical reports are mostly case reports. However, we have encountered a large number of such deformities in our works. In all our deformity cases, the incidence rate of this deformity is relatively low, but the actual number of cases is not small.

The flat pectus carinatum is a special deformity named by us, which is characterized by the overall protrusion of the anterior chest wall, but there is longitudinal depression in the middle. This deformity cannot be corrected by ordinary pectus carinatum surgery. Our method is the combination of Wenlin procedure and Wang procedure, which can achieve ideal results.

Groove chest is another deformity we named ^[10]. From the overall classification, this kind of deformity belongs to the depression type, but since the depression is a transverse groove rather than a pit in the lower part of the anterior chest wall, it is not pectus excavatum, but an independent new deformity. Since the two sides of the depression are open, without closed protrusive edges, Nuss procedure is not suitable due to the lack of supporting points for the steel bar. We designed a special operation for this kind of deformity, which can obtain satisfactory results.

Saddle chest is also our named deformity ^[11]. There are two depressions in this deformity, which are located at the lower part of the chest wall on both sides. The depressions exist symmetrically, but are not connected in the middle, and the height of the middle part is normal. The saddle chest looks like a saddle, so we name it saddle chest. This kind of deformity can be treated with Wenlin procedure or Wang procedure, both of which can achieve good results.

The above-mentioned deformities are all simple deformities. In addition to these deformities, there are a large number of complex deformities in clinic, which have both depression and protrusion simultaneously. These deformities exist in two forms: one is the deformity with a special name, and the other is the deformity without a special name. The former mainly includes Poland syndrome, thoracic dysplasia syndrome, and asphyxiating thoracic dystrophy (ATD) (Jeune syndrome), while the latter mainly refers to general complex deformities. The treatment of Poland syndrome mainly includes two parts: one is the treatment of bone deformity, the other is the treatment of soft tissue. Thoracic dysplasia syndrome has always been regarded

as a disease of spinal surgery, but from the pathogenesis, it is more suitable for thoracic wall surgery. ATD is an extremely rare disease. Because it is very lethal, most children die in childhood. At present, there is little clinical treatment experience, and the reports in the literature are mostly case reports. Our department is specialized in chest wall surgery, and our professional advantages give us the opportunity to contact more ATD patients. By July 2022, we have completed 34 ATD operations, and this is the largest number of operations in the world. During the treatment, we found that ATD can be divided into two types. The pathological structures of the two types are completely different, so different surgical methods are needed for treatment. We designed multiple surgical methods and achieved satisfactory results ^[37-43].

In addition to the complex deformities with special names, there are also some common complex deformities in clinic. Since there is no fixed rule for the distribution of protrusions and depressions of this kind of deformities, it is impossible to make a specific name. In the past, someone used sandwich surgery to treat it. Our experience is to use Wenlin procedure plus Wung procedure or Wang procedure, and this combination will have a more satisfactory effect ^[44].

From the perspective of pathogenesis, thoracic malformation can be divided into two types: primary and secondary. There is no clear cause for the above-mentioned deformities, so they are all primary deformities. If the deformity has a definite cause, it is a secondary deformity. Secondary deformities are caused by specific causes, such as trauma, surgery, or other factors. The common clinical conditions are as follows: (1) Deformities that fail in plastic surgery; (2) Deformities after chest or heart surgery; (3) Deformities caused by trauma; (4) Deformities caused by infection, such as chronic empyema; and (5) Deformities caused by other factors. All the causes may be various, but their common results are that they cause abnormal appearance of chest wall, which are all secondary deformities. We have received four cases of special deformities patients, who suffered severe deformities of chest wall due to abortion during the fetal period. This is the most special case we have encountered.

Secondary deformities are often difficult to operate for three main reasons: (1) The degree of deformity is often very serious; (2) There is serious adhesion; and (3) There are additional lesions. These reasons make secondary deformities treatment a great challenge. Our experience is that the combination of plastic surgery and reconstruction methods can achieve good results.

Reviewing the current status of the treatment of thoracic deformity, the general feeling is that most surgeons are always struggling with the implementation of a certain surgical method. Such a concept is actually contrary to the overall concept of treating thoracic deformity. For this reason, we propose a new concept for the treatment of chest wall deformity, that is, to ignore concrete surgical methods and focus on the correction of the deformity. This concept helps to make personalized surgical design according to the needs of deformities, so as to obtain the best surgical effect ^[23, 24].

3. Progress in the treatment of chest wall tumors. Chest wall tumor is a common disease in chest wall surgery, and its surgical treatment has a history of many years. Generally speaking, the operation includes two basic contents: first, tumor resection, and second, chest wall reconstruction ^[45]. Tumor resection is a mature technology, and recent advances mainly focus on the reconstruction materials ^[45, 46]. Matrix RIB was originally used as a material for fixation of rib fracture ^[47], but recent studies

have found that this material can be easily used in chest wall reconstruction [48, 49]. Another interesting material is digital material [50]. Digital material is the concept that was proposed by us, which refers to materials obtained by digital processing. The processing procedure of this material includes the following steps: (1) imaging examination of chest wall is made to obtain the data of lesions; (2) the chest wall structure was simulated according to the data, and the resection range was designed; (3) the parameters and shapes of materials are designed according to the resection range; and (4) the final materials are processed according to the design results. It can be seen from the process of digital material that since each step is based on the patient's personalized data, the final material can better meet the needs of surgery. This feature fully reflects the advantages of digital materials, and is also considered as the reason for the material to be vigorously promoted. According to different final processing methods of digital materials, they can be divided into two different kinds: one is 3D printing materials [51-53], the other is customized materials [50]. The final processing methods of the two materials are different, but their properties are basically the same. Theoretically, digital materials can better meet the needs of surgery. However, it is difficult to completely transform the theoretical advantages into convenience in operation. The main disadvantages of the use of digital materials are as follows: (1) Licensing problem. Up to now, the application license of digital materials has been the main obstacle restricting their use; (2) Long processing time. Digital materials need to be processed temporarily after the patient is hospitalized. Because the waiting time is too long, it often brings a lot of practical troubles; (3) Obstacles of communication between doctors and engineers. Digital material processing is completed by engineers, but the users are doctors. In order to make the materials very useful, good communication between them is required. But sometimes there are obstacles to such communication; (4) Defects of personalized design. Theoretically, personalized design is the most ideal design, but in many cases, when using these materials, it will be found inappropriate. This shows that the personalization of theory is sometimes difficult to achieve. In general, although digital materials are an ideal concept, more efforts are needed to make them truly practical.

4. Progress in treatment of chest wall infection. There are two kinds of chest wall infection: one is primary infection, the other is secondary infection. Primary infection is relatively rare, but secondary infection is common in clinic. The most common is incision infection after heart or chest surgery, followed by infection caused by various reasons. The chest wall infection is complicated and the treatment is very difficult. The most important development in recent years is the application of negative pressure wound therapy [54, 55]. A large number of clinical experience shows that this is an effective treatment or adjuvant treatment.

5. Progress in treatment of chest wall trauma. Thoracic wall trauma is an ancient chest wall disease, which needs to focus on the treatment of various fractures. In recent years, more attention has been paid to the fixation of rib fractures under thoracoscope. We tried to use MatrixRIB to fix rib fracture under thoracoscope, and achieved ideal results.

6. Progress in the treatment of chest wall defects. Chest wall defect is a special disease in chest wall surgery, which can exist independently or in other chest wall diseases. According to the different causes of the disease, it can be divided into primary defect and secondary defect. The primary defect is usually congenital. The defect can be located in the lateral chest wall or in the middle of the anterior chest wall. It can involve ribs,

costal cartilage and sternum. Sternum cleft can be regarded as the median defect of chest wall, which is a very rare disease. Secondary defect can occur after operation of chest wall, or after radiotherapy of chest wall lesions. In addition, trauma can also cause secondary chest wall defect. The treatment of chest wall defect is chest wall reconstruction [56]. The primary defect operation is relatively simple, but the secondary defect is often accompanied by infection, so there is a higher requirement for reconstruction. Chest wall reconstruction needs to focus on the structures of chest wall, not only including bone structure, soft tissue, skin, but also the intercostal structures, which can effectively eliminate abnormal respiration and maintain respiratory function after operation.

In summary, chest wall surgery is a new clinical specialty, which has made great achievements in recent years. However, it is precisely because a lot of work has just started, there is still much room for progress. With the continuous spread of the concept of chest wall surgery, more achievements will be made in the related work, which will make this specialty truly mature.

Conflict of Interest

Not available

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Reference

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