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Wang procedure: Background, characteristics and application

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Abstract

Wang procedure is a new method to treat pectus excavatum. Before this operation, there was almost only one choice for the treatment of pectus excavatum, which was Nuss procedure. Nuss procedure is a great operation. However, due to obvious defects, improvement is needed. Since general improvement cannot eliminate some deep-rooted defects, the only way to completely eliminate these defects is to design a brand-new technique. It is against this background that Wang procedure came into being. A large number of clinical practices have shown that this operation not only has many advantages that Nuss procedure does not have, but also can be used in a variety of depression and complex deformities. The appearance of Wang procedure has completely changed the concept of thoracic deformity correction and promoted the progress of technology.

Keywords: Wang procedure, Nuss procedure, pectus excavatum, thoracic deformity, history

Introduction

Pectus excavatum is the most common thoracic deformity. The main feature is the depression of the anterior chest wall. Because it can affect patients from both physiological and psychological aspects, many patients need treatment^[1-5]. This deformity are always found after birth or in childhood, and most of the children will go to pediatric surgery department for help. In this case, the deformity is regarded as a disease of pediatric surgery. Since this deformity itself is a disease of the chest wall, more patients, especially older patients, will visit thoracic surgery department. Therefore, pectus excavatum also becomes a typical thoracic surgery disease. Several years ago, we proposed the concept of chest wall surgery and established the world's first independent chest wall surgery department in 2018^[6, 7]. We treat all diseases occurring in the chest wall as chest wall diseases. Therefore, pectus excavatum, one of the thoracic deformities, naturally becomes a chest wall disease. It is obvious that although pectus excavatum is a deformity that occurs in a specific part of the body, it is treated by three groups of doctors belonging to different specialties. This has become a very interesting clinical pattern. However, these three specialties are not all for the treatment of pectus excavatum. In some hospitals, doctors in the cosmetology department, plastic surgery department and even orthopedics department will also participate in the treatment of pectus excavatum, which makes the treatment of this deformity extremely complicated. With the additional participation of suction cups, physiotherapy and traditional medicine, the treatment of this deformity has become more and more complicated and complex. However, in essence, chest wall surgery is the most professional specialty to treat this disease, the reason of which is mainly related to the nature of chest wall surgery^[6, 7]. This nature is different from that of general thoracic surgery. The main nature of the latter is to treat diseases, but the nature of chest wall surgery is not only to treat diseases, but also to ensure plastic effect^[6, 7]. This nature is obviously more suitable for the treatment of pectus excavatum, a disease located on the surface of the chest wall. However, it is undeniable that pediatric surgery and thoracic surgeons have made outstanding contributions in the early clinical practice. Pectus excavatum is an ancient disease, which has been reported for hundreds of years^[8, 9]. Its surgical treatment has a history of more than 100 years^[8, 9]. In the early days, the surgical method was immature. Later, with the progress of technology, the concepts and techniques of surgery tended to be coincident. Two surgical methods gradually became the mainstream, one was Ravitch procedure^[8, 9], and the other was sternal turnover operation^[10].

These operations are typical open operations. From the nature of the plastic surgery, they belong to destructive plastic surgery^[6, 7]. The biggest advantage of this kind of operation is that the incision is large, the exposure is good, and the operation can be completed under direct vision, so the overall operation is more convenient. However, the convenience of this operation also brings a huge cost to the patient, which is significant trauma and long and unsightly scars after surgery^[8-10]. Open operations continued for many years. When there was no better technology to replace it, this kind of operation was the only effective way to treat pectus excavatum. In the 1990s, the concept of minimally invasive surgery gradually entered the clinic. This concept first came into being in general surgery specialty, and then gradually spread to other specialties. Thoracic surgery was also gradually affected. The first minimally invasive thoracic surgery was small incision surgery, which was gradually replaced by thoracoscopic surgery. Under this background, a very great revolutionary surgery appeared, which is Nuss procedure^[8, 9]. When Nuss procedure was first published publicly, it was named as minimally invasive surgery, which opened the history of minimally invasive surgery for pectus excavatum^[11]. Compared with the traditional open operations, Nuss procedure has incomparable advantages^[8-11]: First, the incision is small, hidden, and has a good aesthetic effect; Second, the injury is significantly reduced, which reduces the trauma of the whole operation; Third, the operation is very simple, as long as the surgeon masters the essentials, it is easy to complete the operation; Fourth, the effect is ideal. As Nuss procedure has particularly prominent advantages, it received attention soon after it was published and became popular worldwide at the fastest speed. Finally, this surgery soon became the standard operation for the treatment of pectus excavatum. Nuss procedure is not only highly praised by doctors, but also adored by patients and their families. For a long time, doctors did not perform other operations except Nuss procedure, while patients and family members did not accept other operations except Nuss procedure. Nuss procedure has almost been deified and become the legal gold standard operation.

However, no operation can be perfect, nor can Nuss procedure, which also has defects. With the increase of application experience of Nuss procedure, its defects are gradually revealed. These defects include^[3-5]: (1) the surgery has a high risk. The Nuss procedure requires a special steel bar to be placed in the space between the sternum and the heart. In the presence of anterior chest wall depression, the space between the heart and sternum is very narrow. If the steel bar is placed without a clear field of vision, it may be inserted into the heart, leading to serious complications. Once this complication occurs, there is almost no chance of rescue. This is the most serious defect of Nuss procedure. In order to avoid such a defect, doctors all over the world are making efforts, hoping to eliminate this risk through various methods. However, since Nuss procedure cannot ban the operation of placing steel bars, all efforts are in vain. Taking the use of thoracoscopy as an example, it is reasonable to say that under the observation of the thoracoscopy, it should be possible to completely avoid damaging the heart. However, the cruel reality is that almost all the unfortunate cases that occur every year come from thoracoscopic surgery. It can be seen that the risk of heart injury cannot be completely eliminated. As long as Nuss procedure is performed, this risk is inevitable; (2) May lead to secondary new deformities. In Nuss procedure, when the depression deformity is supported by the steel bar, two new deformities may be formed, one is the protrusion caused by overcorrection, and the other is the

secondary saddle chest caused by the compression of the steel bar^[12]. The former deformity can be eliminated by improving technology, but the latter is another insurmountable disadvantage of Nuss procedure. The Nuss procedure needs to use the steel bar, and the steel bar must have a supporting point. If a large force is required for supporting, this force will be loaded on the ribs at the fulcrum. If these ribs are not hard enough, they will be compressed into a depression, thus forming a secondary saddle chest; (3) there is a limit on the age of surgery. There has been controversy about the most appropriate age for Nuss procedure, but the recognized age contraindication is children with pectus excavatum under 3 years old. Because many patients have severe pectus excavatum at birth, their anterior chest wall severely compresses the heart and lungs, and they need to relieve the compression as soon as possible, but Nuss procedure cannot be used in this age group, therefore, it is difficult for these children to be treated; (4) Defects of Nuss procedure surgical materials^[13]. The classic Nuss procedure uses a special steel bar. After this bar is put into the body of the patient, it needs to be fixed with special fixation plates at both ends. The fixation plate has a large volume, which will occupy a large space after being put into the incision. The plate not only affects the operation and the healing of the incision, but also needs a large incision to include it. Therefore, the design of this fixation plate is a serious defect. In addition, there are a large number of concave teeth at both ends of the main plate. When it passes through the mediastinum, these concave teeth will cut the passing tissue like saw teeth. This is a very dangerous design. Therefore, this design is also an obvious defect; (5) the principle of Nuss procedure itself has defects. From the basic principle of plastic surgery, Nuss procedure belongs to mechanical external force plastic surgery^[6, 7]. Although this kind of operation has certain effects, it is not the most ideal method from the perspective of plastic surgery; (6) Defects of indirect correction. Another feature of Nuss procedure is indirect correction, that is, correct the deformity from a distance through a steel bar, but does not directly correct the local part of the depression. For pectus excavatum with soft bone or no special lesions in the depressed part, indirect correction is not too big a problem. However, some deformities are extremely serious locally, such as those with acute angles. If the deformity is not corrected directly, it is difficult to really change their shape. This is the root cause of the failure of many Nuss procedures.

From the above analysis, it can be seen that Nuss procedure is not a flawless operation. On the contrary, if its defects are carefully studied, it is almost certain that this operation is not a good one. In order to better treat patients with pectus excavatum, it is necessary to choose better surgery. In the era of Nuss procedure dominating the clinic, there is only one choice, that is, to improve Nuss procedure. In order to achieve this goal, doctors all over the world have made great efforts to improve from all angles, hoping that Nuss procedure can abandon defects and become safer and more perfect. Fortunately, the improved Nuss procedure has indeed made a lot of progress, but some deep-rooted defects still cannot be eliminated, such as the safety of surgery, and there is hardly any progress.

All kinds of signs show that it is difficult to completely eliminate the disadvantages of Nuss procedure by relying on the improvement of partial technical details alone, so there is only one way left, that is, to completely abandon this surgery and design a different surgery with a brand-new surgical concept.

In 2018, 20 years after Nuss procedure was announced, a new surgery was born, which is the later Wang procedure^[3-5] (Fig. 1). The reason why Wang procedure appears is precisely to

eliminate the defects of Nuss procedure.

Wang procedure is an operation to correct the depression through the incision on the surface of the chest wall. The concrete details of the operation are the following^[3-5]: At first, an incision in the deepest part of the depression was made, and the soft tissue on the surface of the bone structures were freed. Then a tunnel was built on the chest walls on both sides, and a special steel bar was inserted into the tunnel. Finally, the depressed chest wall structures were lifted and fixed on the steel bar with steel wires to completely eliminate the depression of the chest wall.

It can be seen from the details of Wang procedure that this operation has the following advantages^[3-7]: (1) Absolute safety. First of all, all operations are completed under direct vision. Because the surgical field is very shallow, there will be no risk; Secondly, because the steel bar is placed on the outer surface of the bone structures, it does not need to be placed between the heart and the sternum, so the risk of heart damage is avoided; (2) Extremely simple. Since this operation only needs to place the steel bar on the depression surface, and then lift and fix the depression, there is no technical difficulty, and it is easy to master the technical essentials; (3) It can be used in young children. Young children have soft bones and are more likely to be lifted up, so the younger the age, the better the surgical effect; (4) Direct correction. The operation of Wang procedure is directly aimed at the deepest part of the depression, so it can directly eliminate the depression, making the operation more accurate, and ensuring better results; (5) Template plastic surgery. From the perspective of the nature of plastic surgery, Wang procedure belongs to template plastic surgery. This method is the highest level of plastic surgery, which gives Wang procedure a better effect.

The advantages of Wang procedure are just the characteristics that Nuss procedure does not have. Wang procedure eliminates the defects of Nuss procedure, so it is a new surgery superior to Nuss procedure in many aspects.

Wang procedure was originally designed for young children with pectus excavatum. Children at this age are not suitable for Nuss procedure, which can be an important supplement to Nuss procedure. In the later application process, it was found that Wang procedure was especially suitable for pectus excavatum surgery on some special occasions: (1) Reoperation after pectus excavatum surgery failed^[14]. After the first operation, these patients usually have severe adhesion behind the sternum. If Nuss procedure is used again, it is not only difficult to place the steel bar but also has a great risk, so it is not suitable for Nuss procedure. However, Wang procedure is mainly performed on the surface of bone structures, and it does not need to pass through the post sternal adhesion, so it is not only safe but also simple; (2) Pectus excavatum after cardiac surgery^[15]. The operation of this deformity is similar to the failure of pectus excavatum operation. As there is severe adhesion behind the sternum, Wang procedure is also suitable; (3) Pectus excavatum with deep depression. If this kind of deformity is directly operated by Nuss procedure, it is difficult to place the steel bar. In addition, it is difficult to eliminate the depression with ordinary techniques. Wang procedure directly operated on the local part of the depression. In this process, not only correction but also reshaping could be performed^[16]. All these techniques can help Wang procedure to achieve satisfactory results, so this kind of deformity is more suitable for Wang procedure.

Although Wang procedure is designed for pectus excavatum, the essence of it is depression deformity. Therefore, besides being used for pectus excavatum, Wang procedure can also be used in

all other special deformity with depression. These deformities include: (1) Asphyxiating thoracic dystrophy (ATD)^[17-20]. Since the chest wall of type II ATD has obvious depression, Wang procedure can be used for correction^[17]. In addition to using Wang procedure directly, we also use Wenlin procedure for correction, which can be regarded as a combination of two Wang procedures^[18-20]. When these operations are used, the effect is significantly better than Nuss procedure; (2) Poland syndrome. The main feature of this deformity is that the soft tissues and bone structures of one side of the chest wall are underdeveloped. Because some patients have a depression of one side of the chest wall, Wang procedure can also be used; (3) The lateral chest wall depression^[21]. This abnormal depression exists in one side of the chest wall and does not involve the sternum. It is an independent deformity and has nothing to do with the general pectus excavatum, nor is it an asymmetric pectus excavatum. Since there is a simple depression, Wang procedure can be used for correction; (4) Saddle chest^[12]. This deformity is a symmetrical depression of the lateral chest wall, and we usually use Wenlin procedure to correct it. Since this operation is equivalent to two Wang procedures, Wang procedure can also be directly performed on both sides of the chest wall, and satisfactory results can also be obtained; (5) Groove chest^[22]. The treatment of this kind of deformity is complex, and it cannot be treated by a single operation. The ideal way is to perform Wang procedure^[23] first to change the groove chest into the saddle chest, and then correct the saddle chest. At this time, the saddle chest can be corrected by Wang procedure; (6) Flat chicken breast. This is a very special deformity. Because there is a large area of protrusion of the anterior chest wall with local depression at the same time, the depression needs to be treated. Since the depression position is special, which is not suitable for Nuss procedure, Wang procedure is its only reasonable choice; (7) Wenlin chest^[24, 25]. This deformity also has prominent protrusion and depression. For the treatment of the depression, either the Wang procedure or the general Nuss procedure can be used. However, if the Wang procedure is used, the operation can be completed through the median incision at the same time, which not only avoids entering the thoracic cavity, but also greatly simplifies the operation, so as to achieve the goal of true minimally invasive; (8) Complex deformities^[26]. The above-mentioned deformities, except Poland syndrome, lateral chest wall depression and groove chest, are all complex deformities with both protrusion and depression. Because of its obvious characteristics, they all have specific names. Some deformities also have protrusion and depression, which are general compound deformities because of their irregular shapes. There is no specific position and shape of protrusion and depression, so their operations need to be designed according to specific characteristics. However, for the depression deformity, Wang procedure is often a suitable option, and the operation details can be determined according to the actual situation.

Obviously, although Wang procedure is designed for pectus excavatum, it has a wide range of practical uses and can be used in almost all cases where there is a depression deformity. The appearance of this operation is of great significance. It not only makes the treatment of pectus excavatum undergo great changes, but also provides a good surgical method for many other deformities.

After the appearance of Wang procedure, the chest wall deformity and related operations can be examined with a large field of vision. First of all, all deformities can be divided into two categories, one is protrusion deformity and the other is

depression deformity [27]. Surgery for deformities can then be classified. There are two kinds of surgeries for protrusion deformity, one is Abramson procedure [28], and the other is Wenlin procedure [29-31]. There are three kinds of operations for depression deformity, one is Nuss procedure [8, 9, 11], one is Wang procedure [3-5], and the other is Wung procedure [15, 16, 23, 32]. After such classification, the general situation of deformity treatment is clear. This vision plays a very good role in treating deformities in the best way.

At present, most doctors' treatment for deformities is still limited to a specific operation. Take pectus excavatum for example, surgeons around the world are still discussing Nuss procedure endlessly. This is not only backward in concept, but also backward in technology. It is a clear fact that pectus excavatum cannot be perfectly treated by Nuss procedure in many cases. However, if surgeons set vision higher and farther, do not stick to a specific operation, and choose a more appropriate operation according to the needs of deformities, the treatment effect may change fundamentally. In order to achieve this goal, we proposed the Wenlin principle for the treatment of pectus excavatum [33, 34]. Under the guidance of this principle, completing the operation of deformity will achieve completely different results. These results are obviously much better than that achieved by others using specific operation.

In short, the appearance of Wang procedure not only broke the old concept of the treatment of pectus excavatum, but also provided new ideas and new methods for the treatment of all thoracic deformities, and finally made outstanding contributions to the development of chest wall surgery.

However, just like the great Nuss procedure, any operation has defects, and the Wang procedure also has defects. This is the content that needs to be continuously improved in the future application process.

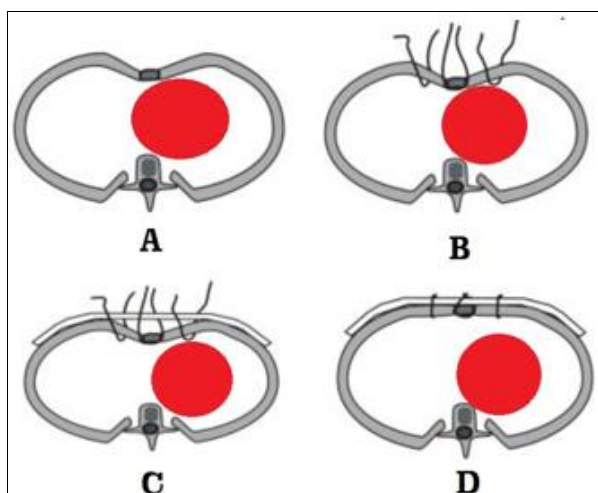


Fig 1: Schematic diagram of Wang procedure

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