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# Reoperation for chest wall deformity after repair of cardiac rupture caused by NUSS procedure: Wung procedure

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**Abstract**
We received a 22-year-old male patient with pectus excavatum recently. The patient underwent Nuss procedure in the local hospital 2 years ago. During the operation, his heart was ruptured during the placement of the steel bar. After emergency treatment, the heart was repaired successfully, and the deformity was corrected with a steel bar. However, the postoperative effect was poor, the appearance of the anterior chest wall did not change significantly, and symptoms gradually emerged. We performed a second operation for the patient, using Wung procedure to complete the correction, and achieved satisfactory results. This article reports the reoperation.

**Keywords:** Pectus excavatum, Nuss procedure, cardiac rupture, reoperation, Wung procedure

## Introduction
There are five basic diseases in chest wall surgery, among which deformity is the most common one [1-3]. In all kinds of deformities, pectus excavatum is the most common kind. The treatment of this deformity has a long history. In early years, open surgery was mainly used. In 1998, after Nuss procedure was reported, the treatment of pectus excavatum entered the era of minimally invasive surgery [4-6]. Nuss procedure has many advantages, but it also has definite defects. The biggest defect is the risk of heart injury [7]. Once the injury occurs, most patients will die. We recently received a patient with pectus excavatum after Nuss procedure. The patient had experienced heart rupture during Nuss procedure. Although the rescue was successful, the effect of deformity correction was poor. We performed another operation for him and achieved satisfactory results.

## Case Report
The patient was a 22-year-old male with pectus excavatum. He was diagnosed in childhood, but there were no obvious symptoms, so he had not received any treatment. After puberty, the chest wall depression becomes obvious, and the patient was not satisfied with the appearance of the chest wall, thus he was eager for treatment. The patient underwent Nuss procedure at local hospital when he was 20 years old. His heart was punctured when the steel bar was placed during the operation, and he developed a severe hemorrhagic shock. After rescue, the heart rupture was repaired, and his deformity correction operation was continued. A steel bar was used to correct the deformity, and the operation was finally completed. However, the surgical effect was not satisfactory. The deformity still existed after operation, and the appearance of chest wall did not improve significantly. The patient did not have any discomfort before the operation, but after the operation, he had palpitations, chest tightness, respiratory discomfort, and could not exercise vigorously. In order to thoroughly treat the deformity, the patient came to our hospital for another operation recently. Preoperative physical examination showed that the lower part of the anterior chest wall was flat, and the middle part was sunken. There were five scars in total on the chest wall, two on both sides of the chest wall respectively, and one transverse longest scar on the left front chest wall, about 15cm long, perpendicular to the scar of the side chest wall (Fig 1). The preoperative imaging examination showed that the lower part of the anterior chest wall was depressed, the heart was compressed, and there was a steel bar in the chest. The most prominent part of the steel bar was not at the bottom of the anterior chest wall depression (Fig 2, 3). The patient's diagnosis was clear and the operation was performed under general anesthesia after full preoperative preparation. The supine position was adopted.

Two incisions were made through the scars on both sides of the chest wall to expose the ends of the steel bar (Fig 4A), and then the steel bar was taken out. During the operation, extensive adhesion was found in the bilateral thoracic cavities, and the heart, lung and chest wall were completely adhered together, making separation extremely difficult. Another incision was made along the scar of left anterior chest wall to expose the space between chest wall and heart and lung under direct vision. After two tunnels were made behind the depressed sternum, two arc steel bars were inserted into the tunnels to support the depressed chest wall respectively, with both ends of the bars being fixed on the ribs of the side chest wall by Wang Technique [8]. Drainage tube were placed in both sides of the thoracic cavity, and the incisions were closed to end the operation (Fig 4B). The operation was smooth without complications. The deformity disappeared completely and the chest wall returned to normal shape (Fig 5). X-ray examination showed that the positions of the steel bars were normal and the shape of the thorax was satisfactory (Fig 6). The patient was discharged 9 days after operation.


**Fig 1:** Appearance of chest wall before operation. A. Positive view; B. Side view

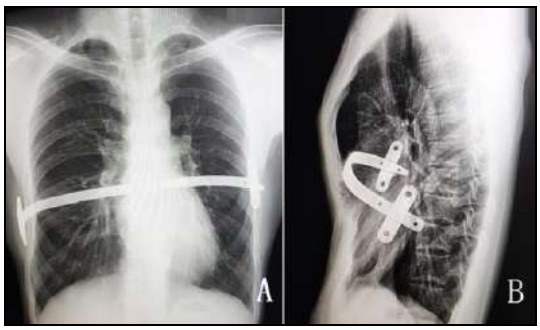


**Fig 2** Preoperative X-ray examination. A. Positive view; B. Side view

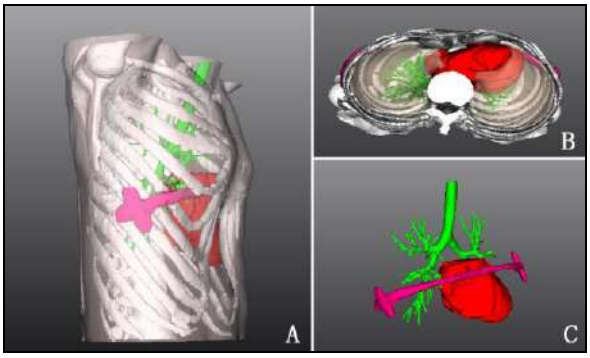


**Fig 3:** Preoperative three-dimensional images. A. Side view; B. Bottom view; C. The relationship between steel bar and heart


**Fig 4:** Surgical pictures. A. Fixation of the end of the bar of the first Nuss procedure; B. Postoperative incision.


**Fig 5:** Postoperative appearance of chest wall

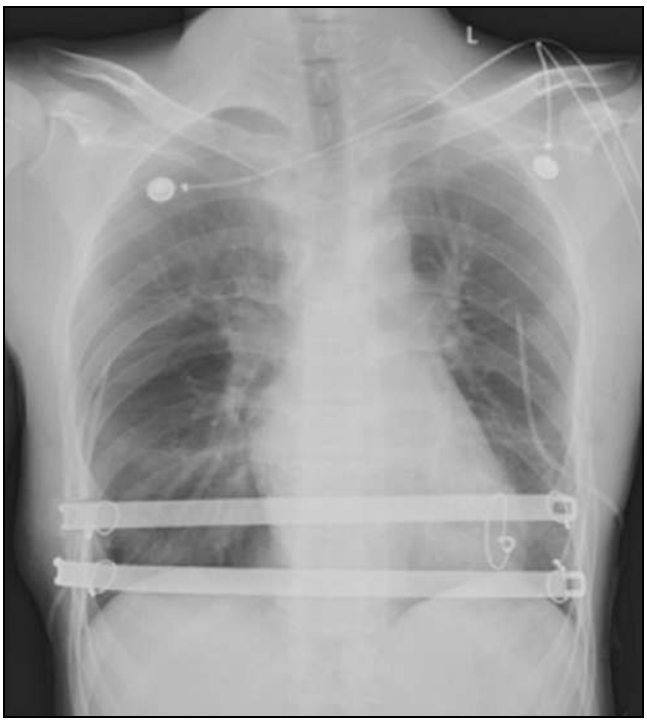


**Fig 6:** Postoperative X-ray examination

## Discussion

Pectus excavatum is the most common thoracic deformity, and Ravitch procedure was the representative operation for this deformity in early years [1-3]. Because of the large injury and long scar, this procedure was not an ideal choice. After Nuss procedure appeared, it soon became the standard operation for pectus excavatum because of its clear

advantages [4-6]. However, this kind of operation also has many defects, among which the risk is the biggest disadvantage [7]. In the process of Nuss procedure, the steel bar must be placed through the heart surface. Because this process is often completed without direct vision, it may lead to heart injury. Once the injury occurs, it often leads to death of patients. This fatal complication limits the large-scale use of Nuss procedure [7, 9-12]. Another disadvantage of Nuss procedure is that the surgical effect is not easy to control. This is mainly because many doctors do not understand the basic principle of this surgery. The principle of Nuss procedure is actually the lever principle, which should have been discovered earlier, but it was only recently clarified by us [13]. Since most doctors do not understand the principle of this procedure, it is difficult to ensure that the surgery can be successfully completed.

In this patient's first Nuss procedure, he experienced the most serious complications, his heart was punctured, and he would have lost his life if not saved in time. Unfortunately, his deformity was not corrected satisfactorily. The reasons were related to three factors: First, the steel bar was placed at a higher position, not on the most depressed plane; Second, the steel bar rotated axially, which could not support the depressed chest wall; Third, there was a problem with the fixation of the two ends of the steel bar. Since the bar was fixed with a short fixing plate but not with the ribs, it cannot ensure the firmness of the fixation [8]. These three factors were actually related to the misunderstanding of the basic principle of Nuss procedure [13]. If the essence of the principle cannot be understand, the failure of this procedure will be inevitable.

The operation of this patient was reoperation. Due to severe adhesion, it will be a great risk to perform Nuss procedure again. For this type of deformity, we recommend Wang procedure as the first choice [9-12]. But for this patient, since there was a long horizontal surgical scar on the left anterior chest wall, we could make the best use of it. After making an incision through this scar, the separation of the adhesion in both thoracic cavities and the posterior sternal space could be completed under direct vision, thus greatly reducing the risk and difficulty of the operation, and making other surgical options possible. Since the patient was an adult male with hard bones and needed greater strength to correct the depression, we chose Wung procedure instead of Wang procedure [14-18]. In essence, Wung procedure is a modified Nuss procedure [14]. Because the adhesion was safely and effectively separated, the Wung procedure could be easily completed. During the operation, we used two steel bars to complete the correction, so that the deformity could be corrected to the maximum extent.

After the failure of pectus excavatum surgery, a variety of complex situations may occur, so the surgery cannot be stereotyped, and personalized treatment decisions should be made according to the actual condition. At this time, the purpose of surgery is not to complete a specific operation, but to use all possible means to obtain the best orthopedic effect [19-20]. This patient had experienced cardiac rupture, with long scars on the left anterior chest wall and also on the lateral chest wall. After these features were well utilized, the operation could be completed as easily as possible.

## Conclusion

Although Nuss procedure has many advantages, it also has many defects. In addition to the risk of death, failure to understand the basic principles may lead to failure of surgery. For failed cases, if the patient want to have another operation, a personalized surgical design must be made according to the specific situation of the patient, so that the successful operation can be completed.

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## Author's Contribution

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## Conflict of Interest

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