Our experience of using Nuss thoracoplasty as a method of correction of pectus excavatum

Abstract. Background. Pectus excavatum is a defect in the development of the chest, often a manifestation of dyshistogenetic syndromes. In 1998, Nuss and colleagues reported on a new method for minimally invasive correction of pectus excavatum. The undoubted advantages of the Nuss procedure are minimal invasiveness and maximum cosmetic effect. However, many authors point to a rather high incidence of complications when using this technique. The purpose was to evaluate the results of surgical treatment of pectus excavatum using Nuss procedure. Material and methods. The study involved 97 patients with pectus excavatum, who underwent minimally invasive correction according to the Nuss method. The study was conducted in the spinal surgery clinic of the State Institution “Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine” from 2015 to 2018. Results. In 83 (85.5 %) patients, we managed to achieve the perfect cosmetic result. In 88 (90.7 %) persons, we used one fixation device, in 6 (6.1 %) patients — 2, in 3 (3.2 %) — 3 fixation devices. The following complications were detected: in 10 (10.3 %) cases — pneumothorax, in 2 (2.06 %) — hemothorax followed by pleural puncture, pneumonia was diagnosed in 2 (2.06 %) patients, pleural effusion — in 2 (2.06 %), empyema — in 1 (1.03 %), seroma — in 1 (1.03 %), deep infection — in 1 (1.03 %). One patient (1.03 %) underwent repeated operation due to the dislocation of the fixation device. At present, fixation devices were removed in 46 patients (47.4 %), the final results of these patients were considered to be good directly during discharge and at follow-up after 1 month. Conclusions. Nuss procedure is the least traumatic surgery for the correction of pectus excavatum and is applicable in children from an early age. In turn, we consider 13–16 years as the optimal age for the operation. The rationale for this is that changes in the heart and lungs at this age are reversible, and the fixation devices are in the body until the end of child’s growth, which reduces the risk of recurrence of the deformity to virtually zero. Keywords: pectus excavatum; Nuss procedure

Introduction

As of today, pectus excavatum remains a serious medical and social problem [1, 2]. Pectus excavatum is presently considered a result of hyaline cartilage dyschon-drogenesis leading to an outpacing rib growth; hence, a prevailing opinion about a radical thoracoplasty associated with an extensive sub-supracartilaginous resection of deformed ribs being the only pathogenetic method of surgical treatment. In 1998, Nuss et al. suggested a new method of pectus excavatum surgical treatment providing an instant correction of all multidimensional chest de-

formation components without any resectional thoraco-plasty [1-3]. To remodel the anterior chest wall, he used a retrosternal metal fixative and avoided resection of rib cartilages.

The Nuss procedure has a number of advantages, namely minimal invasiveness, reduced duration, minimal blood loss and early recovery. During the two recent decades, a significant number of articles were published describing its use in young patients. However, the issue of an ideal age for this minimal invasive procedure remains moot. Most authors suggest

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a surgical intervention being performed at the age of 5-20 years; others opt for 8-12 years due to a greater malleability of chest wall [2-4]. Some authors dispute the applicability of the Nuss procedure in adolescents altogether, as it leads to a growing number of complications and inadequate effectiveness [5]. However, this procedure has lately been indicated for adults as well [6, 7], even despite the frequently reported complications and post-operative pain [5, 7-9]. Since then, the indications have been growing and, as of 2013, we’re performing the Nuss procedure both in children and adults with pectus excavatum.

The purpose is to evaluate the results of funnel chest deformity surgical treatment using the Nuss procedure.

Materials and methods

The sampling population. The study involved 97 patients with pectus excavatum, who underwent a minimally invasive Nuss procedure, their average age being 24±4 years (from 14 to 43), 78 (80.4 %) of them male and 19 (19.6 %) female. The study was conducted in the spinal surgery clinic of the State Institution “Institute of Traumatology and Orthopedics by the National Academy of Medical Sciences of Ukraine” in the period from 2015 to 2018. Among the procedure’s indications there was a cosmetic defect of anterior chest wall, and depth of sternum sinking of over 2 cm (Fig. 1). Prior to the intervention, all the patients underwent clinical examination, X-ray; their Gizhytska index was calculated. We also analyzed the correction outcomes, duration of hospital admittance, post-operative complications, duration of intervention and presence/absence of pneumothorax at the post-operative X-ray images of patients’ chests.

Intervention method

The patient is lying on his/her back, his/her left limb abducted to catheterize, his/her vein while the right one is bent at the shoulder and elbow joints and fixed to the loop. Intubation was performed by means of a single-opening tube. To the right and left of anterior armpit line, 3 cm–long incisions were made with a further separation of subcutaneous fat from the muscle fascia. The area of fixative passage was also delineated on the right and left. Using trocar, a surgeon perforated the chest cavity 3-4 cm below the right incision and planted a work path. This work path was used for introducing a 30° thoracoscope. Video monitoring enabled a safe introducer and fixative’s passing of deformation peak. While inserting the introducer into the pleural cavity, a surgeon followed an interclavical line into the right 5 or 6th intercostal space. Introducer was moved from right to left, carefully separating the pericardium, to exit from the left pleural cavity at the interclavical level. After that, the fixative was remolded. The remolded fixative was attached to the introducer by a
strip and moved from left to right in the created path. When the fixative rotated at 180°, the correction was achieved. After that, at both fixative’s tips transversal stabilizers were clipped in order to prevent its reverse turning, followed by the final molding of fixative’s tips. The incision was sown together layer by layer. A temporary drainage tube was inserted into the work path and removed after the lungs being inflated at the table. Following the intervention, all patients received narcotic analgesics during 4 days, and after that non-narcotic ones. Physical exertion was prohibited during the next 3 months. Fixatives remained within the patients’ bodies for 3 years and then removed under a general anesthesia.

**Results**

Post-operative examination showed that in 83 (85.5%) patients a perfect cosmetic result was achieved. In 88 (90.7%) patients we used one fixative, in 6 (6.1%) - 2 fixatives, in 3 (3.2%) - 3 fixatives. The number of fixatives was chosen during the procedure depending on the results following the first planting. The average duration was 45±8 minutes (from 33 to 98 minutes), the average hospital post-surgery admittance lasted 8 days (from 5 to 11 days). Pleural drainage tube was left for 24 hours only in case of a repeat intervention due to recurring deformities. The next day after the surgery all patients were examined with X-ray to study their lungs in a frontal projection while they were standing. 10 (10.3%) patients had a pneumothorax, however, only two of them (2.06%) required a pleural puncture to perform a Büllau drainage. Two patients (2.06%) had a hemothorax and required a pleural puncture.

Other post-operative complications included pneumonia diagnosed in 2 (2.06%) patients, pleural effusion in 2 (2.06%) patients, empyema in 1 (1.03%) patient, seroma in 1 (1.03%) patient, and deep infection in 1 (1.03%) patient.

One patient (1.03%) underwent a second operation due to the dislocation of a fixative. At present, fixatives are removed in 46 patients (47.4%), the outcomes of these procedures determined to be good directly during the discharge and at a follow-up after 1 month. Unfortunately, we’re lacking long-term observational data on patients with fixatives removed.

A sample pectus excavatum correction is presented in Fig. 2.

**Discussion**

In 1998, Nuss et al. [1] presented a minimally invasive alternative of the standard open Ravitch procedure for pectus excavatum, the reason being given that an extensive and radical rib cartilage resection was no longer necessary and correct sternum positioning could be relatively easily achieved.

This minimally invasive procedure has a number of obvious advantages:

1) absence of a big incision on an anterior chest wall, no need of chest muscle flaps being separated and rib cartilage resected and/or sternal osteotomy performed;

2) short duration of procedure, minimal blood loss and early recovery;

3) quick recovery of muscular strength, chest expansion, its flexibility and elasticity restored;

4) optimal long-term cosmetic effect in children [1].

Thoracoscopy navigation being added and certain methods slightly modified, this procedure became safe and very effective. Since then, there were a lot of studies published, confirming the safety of this procedure for children and adolescents. Most are relatively minor in terms of patient sampling; however, some of them are based on a long-term experience [2, 9, 10]. The numbers of patients who have been exposed to the procedure and surgeons who have perfected it are rising steadily since then, and nowadays the Nuss procedure is considered golden standard in pectus excavatum treatment.

Treating adults with pectus excavatum by means of the Nuss procedure remains contentious. The open procedure described by Ravitch [11], by contrast, has been in use for decades and still performed at many clinics [12 - 16].

90% of published studies cite a patient’s complaint of a cosmetic defect represented by formal anomaly of anterior chest wall among the indications for pectus excavatum surgical correction [17]. Several studies also state that pectus excavatum correction resulted in an improved life quality [17, 18]. Ravitch procedure presupposes a long vertical or horizontal incision in the anterior part of chest wall, rib cartilage resection leading to an ossification of a new cartilage and stiffening of the anterior wall. In most cases, a metallic fixative shaft is also required in order to mold a flat chest.

One of the conservative methods of pectus excavatum correction is a vacuum bell jar requiring a vacuum suction cup being affixed to the patient’s chest for 1-8 hours daily during 12-36 months. This method is rather effective in children younger than 10 years, and to a less extent — in adolescents and adults. However, it is impossible to remove this deformity only by means of a vacuum bell jar [19].

Having undergone the Nuss procedure, the patients reported and increased range of physical capacities [18, 20, 21]. Some authors [19, 21] showed that prior to the operation cardiac activity of patients with pectus excavatum amounted to 80% of age norm, while 3 years after the operation cardiac and pulmonary indices reached their optimum. When the right cardiac ventricle was released, its functional parameters improved and turned...
Fig. 2. Various projections of photo and X-ray image of a patient before and after surgery
normal [22]. To the same extent, after the operation chest movement dysfunction was corrected, chest cavity became expanded and breathing act normalized. This is why correction of chest as close as possible to the normal anatomic shape is considered essential for achieving cosmetic results and improving physical capacities. The Nuss procedure makes all of this possible.

The issue of optimum age for the surgery is still under deliberation. When D. Nuss published his first article on the procedure, the patient’s mean age amounted to 6 years, and none of them was older than 15. However, nowadays the mean age is 14 years, and the authors increasingly believe that optimal age is the puberty onset [20]. However, most studies suggest that an advanced pectus excavatum often requires an earlier correction. For instance, H. Park et al. [10], based on the results of 1571 interventions, recommend the age of 5 years, even despite possible deformity recurrence after the fixative being removed, due to the ongoing sexual development.

In our turn, we consider the optimum intervention age to be 13-16 years. Our justifications for this consideration rely on the facts that cardiac and pulmonary changes at this age are reversible and the fixative remains inside a patient’s body until the end of skeletal growth, minimizing the risk of recurrent deformity. Girls at this age start developing breasts, which makes early correction of chest as close as possible to the normal anatomic shape is considered essential for achieving cosmetic results and improving physical capacities. The Nuss procedure makes all of this possible.

Postoperative pain syndrome was often described as the principal disadvantage of the Nuss procedure. For this reason, we recommended our patients to take narcotic analgesics for 4 days after the surgery, and then switch to the non- narcotic ones. After the discharge, patients were taking analgesics for 2-6 weeks.

Conclusions

1) The Nuss thoracoplasty enables a pronounced cosmetic effect compared to other methods of pectus excavatum correction. Main patient-oriented postoperative initiatives are associated with pain syndrome prevention.

2) The Nuss thoracoplasty is considered the least traumatic method of pectus excavatum correction and as such could be used in children since an early age. In our turn, we consider the optimum intervention age to be 13-16 years. Our justifications for this consideration rely on the facts that cardiac and pulmonary changes at this age are reversible and the fixative remains inside a patient’s body until the end of skeletal growth, minimizing the risk of recurrent deformity.

Conflicts of interests. Authors declare the absence of any conflicts of interests that might be construed to influence the results or interpretation of their manuscript.

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血管的正常功能受到影响。血管的正常功能受到影响。
Наш опыт применения торакопластики по Нассу как метода коррекции воронкообразной деформации грудной клетки

Резюме. Актуальность. Воронкообразная деформация грудной клетки (ВГДК) — дефект ее развития, нередко являющийся проявлением дистгистогенетических синдромов. В 1998 году Nuss с коллегами сообщили о новом методе минимально инвазивной коррекции ВГДК. Безусловными преимуществами метода Насса являются минимальная травматичность и максимальный косметический эффект. Вместе с тем многие авторы указывают на достаточно высокую частоту осложнений при использовании данной методики.

Цель: оценить результаты хирургического лечения воронкообразной деформации грудной клетки методом Насса.

Материалы и методы. Обследовано 97 пациентов с ВГДК, которым проведена минимально инвазивная коррекция по методу Насса. Исследование проведено в клинике хирургии позвоночника ГУ «Институт травматологии и ортопедии НАМН Украины» в период с 2015 по 2018 г.

Результаты. У 83 (85,5 %) пациентов нам удалось достичь идеального косметического результата. У 88 (90,7 %) использовали один фиксатор, у 6 (6,1 %) — 2 фиксатора, у 3 (3,2 %) — 3 фиксатора. Среди осложнений у 2 (2,06 %) пациентов определили наличие пневмоторакса, у 2 (2,06 %) — гемоторакс с последующей плевральной пункцией. Пневмонию диагностировали у 7 (7,2 %) пациентов, плевральный выпот — у 2 (2,06 %), эмпиему — у 1 (1,03 %), серому — у 1 (1,03 %), глубокую инфекцию — у 1 (1,03 %). Один пациент (1,03 %) перенес повторную операцию из-за вмешательства на фиксатор. В настоящее время фиксаторы были удалены у 46 пациентов (47,4 %), остальные préc.

Выводы. Торакопластика по Нассу является наименее травматичной операцией для коррекции ВГДК и применима у детей с раннего возраста. В свою очередь, мы считаем оптимальным возрастом для операции 13–16 лет. Обоснованием этого является то, что изменения со стороны сердца и легких в этом возрасте обратимы, фиксатор продолжает оставаться вплоть до окончания роста, что минимизирует возможность рецидива деформации.

Ключевые слова: воронкообразная деформация грудной клетки; операция по методике Насса