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Surgical Correction of Child Pectus Excavatum by TiNi-based Materials

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Abstract

This article describes the serious and urgent issue of surgical treatment of congenital child pectus excavatum and the approaches in the surgical correction of this children pathology. The authors propose an original surgical treatment method in applying TiNi-based materials possessing shape memory in OP treatment of pectus excavatum. Plain integral TiNi-based plasty creates supplemental correction force due to the material isoelastic properties, providing stable fixation of corrected chest section throughout the immobilization period.

1 Introduction

Congenital pectus excavatum is a birth defect associated with chest deformity. The most common is pectus excavatum (PE) [1, 3]. This congenital abnormality is associated with cosmetic defects involving functional diseases of the cardiovasular and bronchopulmonary systems. According to domestic data child pectus excavatum includes 0.06 to 2.3%, while to international data 11].2 to 1,3 % [6, 10,

Surgical treatment of congenital child pectus excavatum is one of the most serious and urgent issues in thoracic surgery in time of childhood. Today, there are numerous thoracoplasty methods of child congenital defects [5, 7, 9]. Improvement and wide-scale implementation of minimally invasive and hi-technology methods in the surgery treatment of congenital pectus excavatum is a step forward [4, 8]. However, there are those urgent and unsolved issues concerning optimal

treatment approaches in selecting the thoracoplasty itself and sternocostal fixation modes.

Surgical correction of pectus excavatum should be in-time and highly-qualified. This, in its turn, improves the cardiovasular and bronchopulmonary system functions and furthers early after-treatment. In this case, we have proposed our surgical treatment method for congenital child pectus excavatum in time when bones grow rapidly. This application involves plain bio-friendly composite materials, including TiNi-based alloys. Such materials have the following properties: bio-inertia, isoelasticity, strength and shape memory effect.

Research objective: To evaluate if titanium nickelide materials possessing shape memory are effective in OP treatment of pectus excavatum.

2 Experimental

43 children patients with were operated in Tomsk Medical University Clinic (table 1).

Table 1 Pectus excavatum patients

Orthopedic pathology	Study group (proposed treatment methods from 2005 to 2015)				
	Sex		Age		Total
	M	F	7-11	12-16	
Pectus excavatum (PE)	39	4	16	27	43

As the Table shows there were 43 pectus excavatum children (24.9%), including 39 boys (90.7%) and 4 girls (9.3%). Age group from 7 to 11 included 16 children (34.9%), and from 12 to 16 included 27 children (65.1%).

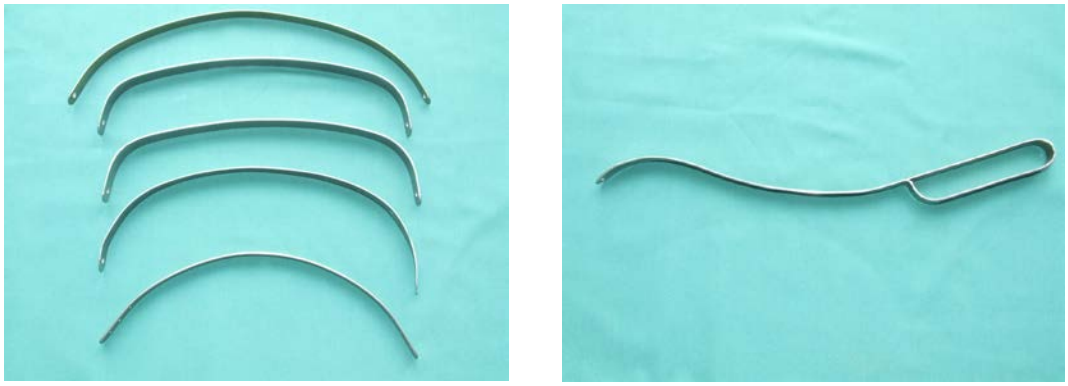
Selecting this or that surgical correction method includes the following factors: general state of a patient, examination data of cardiovasular and bronchopulmonary system, X-ray analysis and CT-examination of chest, and degree and shape of defect. These results determine the following surgical indications for surgical treatment of chest distortion patients:

a) II-III degree chest distortion according to J. Gizycko index (1962);

b) cosmetic defect, causing emotional pain and discomfort; and

c) functional diseases of cardiovasular and bronchopulmonary systems.

Pectus excavatum correction was based on Nuss method custom-tailored TiNi-based instruments and medical shape memory material, produced at R&D Institute, TSU, Tomsk were applied (Fig. 1).



a b

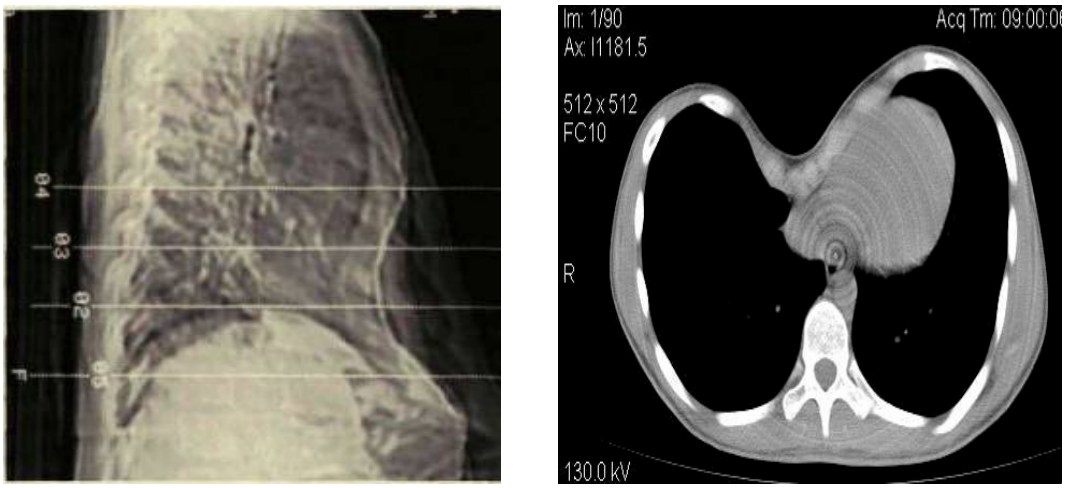
Fig. 1. Set of TiNi-based plasty (a); instrument for substernal tunneling (b)

General chest appearance of pectus excavatum patient before the operation and 3 years after treatment, applying plain TiNi-based plasty of shape memory as presented in figure 2.

a b

Fig. 2. General chest appearance of pectus excavatum patient before the operation (a) and 3 years after treatment, applying plain TiNi-based plasty of shape memory (b)

Overall lateral view of CT-examination (a) and cross-section CT-examination in small location of sternocostal defect (b) as presented in Figure 3.



a b

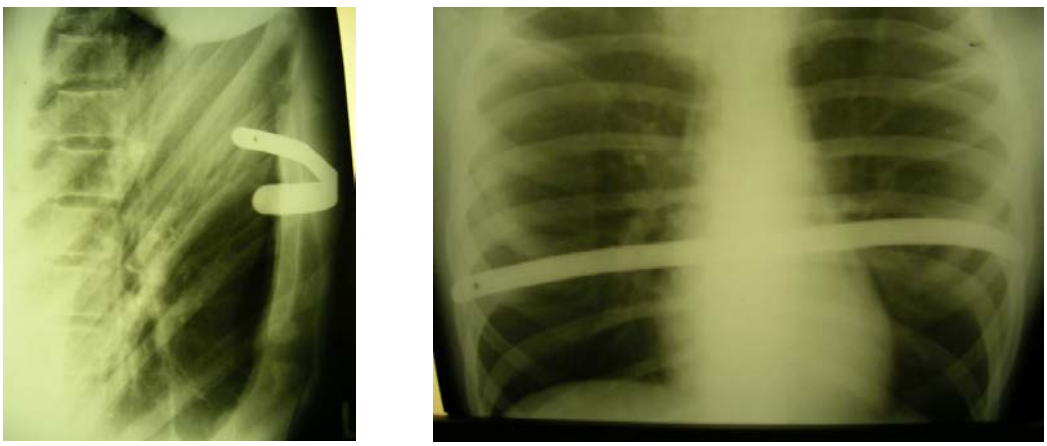
Fig. 3. Overall lateral view of CT-examination (a); cross-section CT-examination in small location of sternocostal defect (b)

Figure 4 shows plasty fitting (a); placing plasty before rotating (b); and plasty rotating (c).

a b c

Figure 4 Plasty fitting (a), placing plasty before rotating (b); plasty rotating (c).

Figure 5 shows patient X-ray in lateral view (a) and frontal view (b) after operation.



a b

Figure 5 patient X-ray in lateral view (a) and frontal view (b) after operation

3 Results and discussion

Surgical correction of pectus excavatum involves surgical interference, causing further complications. In this case, these complications are classified as immediate or delayed postoperation period.

Perioperative and / or postoperative pulmonary complications were in 5 patients (11.6%), where in 4 cases – pneumothorax, and 1 case – hemothorax. Pleural effusion is removed by paracentesis.

Postoperative pulmonary complication as breakage of mylar tape fixing plain titanium nickelide plasty to the rib was in 6 children (13.9%). This complication did not influence the patient treatment. Only in one case (2.3%) in time of progressive growth the scoliosis increased resulting in recurrent chest distortion above the fixed plasty. The second plasty was fixed in the reoperative patient.

Based on the analyzed results it was concluded that unacceptable results could be projected to defects leading to congenital pectus excavatum and spinal anomalies in study group. Such complications as breakage of mylar tape could be associated with patient non-compliance (for example a child is active in wrestling).

Sound preoperative examination of the patients, range of surgical interference on chest with minimal surgical injury and reliable plasty fixation are considered to be the criteria in reducing postoperative complications of pectus excavatum patients and resulting in improving treatment outcome.

Developed method of operative chest defect treatment by applying plain bio-friendly isoelastic titanium nickelide plasty with shape memory made it possible to execute an individual surgical treatment approach. By the provision of increased fixation period by plain TiNi-based plasty, it is possible to reduce recurrent incidences of patients with progressive deformations in time of organism growth. Plain integral titanium nickelide plasty creates supplemental correction force due to the material isoelastic properties, providing stable fixation of corrected chest section throughout the immobilization period.

Clinical application cases of plain TiNi-based implants in surgical correction of pectus excavatum patients showed the following results: good – 86.1% and satisfactory – 13.9% No unacceptable results strongly justify the fact to recommend the described surgical treatment approach for patients with chest deformities by applying plain TiNi-based plasty in practice.

4 Summary

This method of nickelide titanium reconstruction of the chest wall can be applied in cancer patients with large extension of local disease. The method allows to achieve good long-term functional result.

References

[1] K.Yu. Ashkraft, T.M. Kholder, Chest Distortion, Pediatric surgery, St. Petersburg, 1996.

[2] A.V. Vinogradov, Child Chestdeformation: Curgery Treatment and Medic-social Rehabilitation [in Russian], Moscow, 2004.

[3] A.A. Vishnevskiy, S.S. Rudakov, N.O. Milanov, Thoracic Wall Surgery [in Russian], Guideline, Moscow, 2005.

[4] G.V. Slizovskiy, I.I. Kuzhelivskiy, Surgical treathment method of children dysplastic coxarthrosis, Mother and Child in Kuzbass [in Russian]. 3 (2013) 28-32.

[5] A.Yu. Razumovskiy, M.O. Savchuk, A.A. Pavlov, Pectus carinatum, Pediatric Surgery [in Russian]. 1 (2009) 45-50.

[6] V.B. Shamik, Optimal reconstructive thoracoplasty for child and teenager congenital pectus excavatum [in Russian], Rostov-on-Don, 2003.

[7] D. Nuss, Minimally invasive surgical of pectus excavatum, Semin. Pediatr. Surg. 17 (2008) 209-217.

[8] G. Kraspoulos, M. Dusmet , G. Labas , P. Goldstraw, Nuss procedure improves the quality of life in young male adults with pectus excavatum deformity, Europ. J. Cardio-thor. Surg. 29 (2006) 1-5.

[9] M.H. Malek, D.E. Berger , W.D. Marelich et al. Pulmonary function of pectus excavatum: a meta-analysis, Europ. J. Cardio-thor. Surg. 30 (2006) 637-643.