Ann Thorac Cardiovasc Surg 2017; 23: 175–180
Online June 16, 2017
doi: 10.5761/atcs.oa.17-00014

Original Article

Intervention of the Nuss Procedure on the Mental Health of Pectus Excavatum Patients

Li Luo, MD,[1] Bo Xu, MD,[2] Xinling Wang, MD,[3] Bo Tan, MD,[4] and Jing Zhao, MD[2]

Pectus excavatum (PE) is the most common congenital chest wall deformity, but little is known about the influence of the Nuss surgical procedure on mental health of patients with PE. In this study, we aimed to evaluate the influence of the PE Nuss surgical procedure on mental health in Chinese patients and identify the predictors of psychological status for PE. Patients with PE (n = 266) underwent a standard surgical procedure by the same surgeon and did the Symptom Checklist 90 (SCL-90) and the Self-rating Depression Scale (SDS) questionnaires before and 1 year after surgery. Additionally, platelet reactivity of postoperative PE patients was assessed. We found that PE patients after surgery performed better in the questionnaires and the frequency of mental health problems in the patients was lower than before. Most significantly, four mental disorders were alleviated after surgery, namely somatization, interpersonal sensitivity, depression, and anxiety. What is more, age, suffering year, and platelet aggregation responses to serotonin and epinephrine of PE patients partially were involved with the postoperative alleviation of mental disorders. In conclusion, the mental health level of PE patients could be effectively improved via the Nuss surgical procedure, and the earlier surgery might turn out better.

Keywords: pectus excavatum, mental health, surgery, depression, platelet aggregation

Introduction

Pectus excavatum (PE) or "funnel chest" is the most common congenital chest wall deformity, accounting for over 90% of all chest wall deformities, with an incidence rate of approximately 0.1%, and a male to female ratio of 4:1.[1)] PE is sporadic and generally asymptomatic, but due to the inward displacement of the sternum or costal cartilage, the chest of PE patients appears like a funnel. Thus, PE patients often suffer from impaired social interaction, and the self-esteem of PE patients is negatively connected with aesthetic concerns.[2)] Indeed, children with PE displayed higher prevalence of psychosocial problems than children of health control.[3)]

The Nuss procedure is a common and minimally invasive treatment for PE repair. The depressed sternum and costal cartilage are rebounded after this surgery.[4)] The Nuss procedure has the advantages of small and hidden incisions, short operative time, low blood loss, rapid recovery, and no need of cartilage or sternum resections. Yet, some studies on PE patients document about the importance of surgery to improve the quality of life like self-esteem,[5–10)] there is no systematical study to evaluate the psychosocial status in postoperative patients from child to adult. Psychosocial problems could be improved after surgery, but it is not clear whether clinical features are involved.

[1]*Department of Medical Psychology, the Army General Hospital of PLA, Beijing, China*
[2]*Department of Thoracic Surgery, the Army General Hospital of PLA, Beijing, China*
[3]*Department of Information, the Army General Hospital of PLA, Beijing, China*
[4]*International Travel Health Care Center, Xinjiang Entry-Exit Inspection and Quarantine Bureau, Xinjiang, China*

Received: January 16, 2017; Accepted: February 14, 2017
Corresponding author: Jing Zhao MD. Department of Thoracic Surgery, the Army General Hospital of PLA, Beijing 100700, China
Email: zhaojin0321@126.com

Table 1 Demographic characteristics of patients with pectus excavatum

Characteristics	PE patients
Subjects	266
Age*	19.02 ± 4.42
Gender	
Male	228
Female	38
Education	
≤Junior middle school	68
Senior middle school	87
≥College	111
Marital status	
Unmarried	259
Married	7
PE status*	
HI	4.18 ± 1.20
Suffering year	9.78 ± 6.30

*Data given as mean ± SD. PE: pectus excavatum; HI: Haller index

To unfold the above issues, our study evaluated the mental health problems of PE patients by using Chinese Mandarin version of the Symptom Checklist 90 (SCL-90) and the Self-rating Depression Scale (SDS) questionnaires, and analyzed the risk factors of psychosocial problems for postoperative patients. Expectedly, after the Nuss procedure, mental disorders of PE patients had been remarkably alleviated. Yet, older age seamed weaken this improvement. We believed that the earlier to be operated, the better intervention of psychosocial problems for PE patients.

Methods

Subjects

This study was approved by the General Hospital of Beijing Military Region (Beijing, China) ethics review board and we got the informed consent of all subjects for adults and parents for those under age 18 years.

In all, 266 patients with PE were recruited of admission date from 2009.7 to 2012.1. The inclusion criteria were as follows: a diagnosis of PE, intelligence quotient higher than 70, and Chinese as first language. Exclusion criteria for subjects were as follows: having a major psychiatric disorder, previous surgery, recurrent PE, or other complex chest wall deformity. Detailed medical histories of patients were collected, and the Haller indexes (HIs) before and after surgery were calculated according to the chest computed tomography (CT), as shown in **Table 1**.

Surgical procedure

In the process of this study, the same surgeon (Bo Xu) operated a standard surgical procedure for all the patients recruited. The operations were done under general anesthesia as described before.[2] Briefly, both sides of the chest were incised laterally. Then, the surgeon inserted a curved bar into the sternum. Due to varying degrees of deformity in patients, personalized bar was curved. The depressed sternum and costal cartilage of the chest in PE patients could be rebounded by this bar. After fixation of the bar on the ribs, the surgeon sutured conventional incision postoperatively.

Research tools

In this study, two questionnaires were used to measure mental health status 7 days before surgery and 1 year after surgery: the SCL-90 and SDS questionnaires. i) SCL-90 is a current extensive checklist scale for mental disorders and psychological illnesses in outpatient service.[11] The scale included 1–5 levels of evaluation standards, with a total of 90 chapters on 10 factors: 1) somatization, 2) interpersonal sensitivity, 3) obsessive-compulsive symptoms, 4) depression, 5) anxiety, 6) hostility, 7) terror, 8) paranoid ideation, 9) psychoticism, and 10) other items. The scores were divided into five levels: "no, mild, moderate, severe, and serious." The total score was the sum of 90 chapters. When the total score was greater than 160, the number of the positive items was more than 43 or a certain factor was more than 2, which was positive.[12] Furthermore, those positive patients were asked to complete the SDS questionnaire. The SDS, designed by Zung in 1965, is used to measure status of depression as a reliable tool.[13] It contains 20-item questionnaires with responses rating from 1 to 4, and higher scores mean more frequent depressive symptoms. The clinical threshold of the total of the raw item scores is 53, namely patients scoring ≥53 were in depressive status.

Assessment of platelet reactivity

For platelet aggregation analysis, blood samples of 10 ml were obtained from veins at rest and stored into standard commercial evacuated tubes containing 3.8% sodium heparin at −80°C until analysis. The platelet aggregation was assessed as described before.[14] Briefly, platelet-rich plasma was centrifuged at 135 g for 15 min and prepared at 250,000 platelets/μl for use. Then, platelet aggregation responses to different agonists, namely epinephrine, adenosine diphosphate (ADP), collagen

Table 2 Psychological scores before and 1 year after surgery of patients with pectus excavatum

Characteristics	Preoperative	Postoperative	p value
Symptom Checklist 90 (SCL-90)*			
Total average score	152.02 ± 55.04	141.75 ± 19.56	0.037
Somatization	1.57 ± 0.59	1.23 ± 0.62	0.001
Interpersonal sensitivity	1.92 ± 0.72	1.77 ± 0.64	0.025
Obsessive-compulsive symptoms	1.80 ± 0.73	1.82 ± 0.69	0.805
Depression	1.74 ± 0.78	1.57 ± 0.69	0.003
Anxiety	1.73 ± 0.71	1.58 ± 0.73	0.013
Hostility	1.74 ± 0.82	1.70 ± 0.77	0.582
Terror	1.49 ± 0.60	1.51 ± 0.52	0.702
Paranoid ideation	1.62 ± 0.64	1.60 ± 0.68	0.773
Psychoticism	1.56 ± 0.58	1.53 ± 0.55	0.646
Other aspects of symptoms	1.67 ± 0.66	1.57 ± 0.49	0.104
Mental health problems (n)#	161 (60.53%)	79 (29.70%)	<0.001
Depressive status (n)##	153 (57.52%)	76 (28.57%)	<0.001

*Data given as mean ± SD. #When the total score was greater than 160, the number of the positive items was more than 43 or a certain factor was more than 2, a patient was positive for mental health problems. ##Patients scoring >160 on the SCL-90 or having scores ≥3.0 for the depression or the anxiety items were asked to complete the Self-rating Depression Scale (SDS) survey. The clinical threshold is 53. Patients scoring ≥53 were in depressive status.

(Chronolog, Havertown, PA, USA) and serotonin (St. Louis, MO, USA), were assessed. Epinephrine 10 μmol/l, serotonin 10 μg/ml, collagen 10 μg/ml, and ADP 5 μmol/l were tested alone or combined for test. Platelet aggregation responses were recorded and the results presented as % platelet aggregation × time (minutes).[14]

Statistical analysis

All data were given as the mean ± standard deviation (SD) with SAS 9.1 for Windows. A p value below 0.05 is considered significant. The correlation analysis between the psychological status and clinical features of PE patients were tested by a χ^2 test. The differences in mental scores, HI, and suffering year between groups of patients were analyzed by Mann–Whitney U-test (the one of nonparametric test).

Results

All the 266 PE patients did the SCL-90 questionnaires before surgery and 1 year after surgery (**Table 2**). It was shown that the total score, somatization, interpersonal sensitivity, depression, and anxiety scores of SCL-90 after surgery were significantly higher than those before surgery ($p < 0.05$). The obsessive-compulsive symptoms, hostility, terror, paranoia ideation, psychoticism, and other mental disease scores between the two stages were not significant ($p > 0.05$). These indicated that after the Nuss procedure of PE surgery, mental problems of PE patients were alleviated.

As shown in **Table 2**, 1 year after surgery, of all the 266 PE patients, 76 (28.57%) patients still had depressive status. In all the postoperative PE patients, depressive status with clinical features were investigated by the χ^2 test and shown in **Table 3**. We found a significant association between depressive status and older age ($p = 0.039$), or total suffering years ($p = 0.028$) in postoperative PE patients. Gender, education, marital status, or HI had no significant effect on mental depression (**Table 3**). Additionally, HIs of all patients after surgery were measured, and no significant difference was found between patients with and without depressive status (2.59 ± 0.40 vs. 2.65 ± 0.37, $p = 0.236$), suggesting little effect of surgical outcome on depressive status in PE patients.

Furthermore, the 153 depressive PE patients before surgery were divided by postoperative depressive status, namely 76 (49.67%) patients with depressive status and 77 (50.33%) patients without depressive status. Statistical analysis showed that there was a significant association between the consistent depressive status in PE patients and older age ($p = 0.019$) or total suffering years ($p = 0.006$) (**Table 4**). The dyshomeostasis of neurotransmitters like serotonin (5HT) or epinephrine account for

Table 3 Association between demographic characteristics and depressive status of the pectus excavatum patients after surgery

Characteristics	Postoperative patients without depressive status, n (%)	Postoperative patients with depressive status, n (%)	p value
Age			
11–16	63 (33.16%)	14 (18.42%)	0.039
17–22	103 (54.21%)	47 (61.84%)	
≥23	24 (12.63%)	15 (19.74%)	
Gender			
Male	164 (86.32%)	64 (84.21%)	0.803
Female	26 (13.68%)	12 (15.79%)	
Education			
≤Junior middle school	54 (28.42%)	14 (18.42%)	0.222
Senior middle school	61 (32.11%)	26 (34.21%)	
≥College	75 (39.47%)	36 (47.37%)	
Marital status			
Unmarried	185 (97.37%)	74 (97.37%)	0.672
Married	5 (2.63%)	2 (2.63%)	
PE status*			
HI	4.15 ± 1.21	4.28 ± 1.17	0.484
Suffering year	9.23 ± 5.82	11.17 ± 7.22	0.028

*Data given as mean ± SD. PE: pectus excavatum; HI: Haller index

the mental health problems such as depression, and then we measured the platelet aggregation for 5HT or epinephrine in patients of different depressive status. It was revealed that postoperative patients with depressive status had a higher platelet aggregation response to 5HT ($p = 0.012$) and epinephrine ($p = 0.005$) (**Table 4**). No significant differences were found in platelet aggregation response to collagen or ADP, and none to 5HT + epinephrine, 5HT + collagen, or 5HT + ADP. Also, gender, education, marital status, or HI had no significant effect on metal depression.

Discussion

The appearance of a patient with PE is singular, which may serve as a kind of stress to cause psychological trauma. Zou et al.[15] surveyed more than 470,000 students of primary and middle school in Dongguan China, and found that the prevalence of PE was 0.583%. Among those PE patients, the impact of PE on the cardiopulmonary function was not obvious, but was notable on their mental state. Mental problems of these patients were mainly inferiority, shame, social barriers, loneliness, or depression.[15] Also, many other patients of orthopedic surgery have tendency of inferiority. For example, patients with craniofacial anomalies often have appearance concerns and related social anxiety which experienced negative psychological impact,[16] and patients with ankylosing spondylitis show high frequency of anxiety and depression.[17] Thus, it is necessary to follow the psychological problems caused by the physical deformity of patients.

In our study, 153 of 266 PE patients had mental problems before surgery. After the Nuss surgical procedure, patients with PE get maximum correction immediately, but the psychological impact is a chronic and need longer time for observation. Therefore, follow-up study is necessary. One year after surgery, through the follow-up survey, we found that postoperative patients with PE performed better in SCL-90 questionnaire than before, and the improvement was statistically significant. The scores for somatization, interpersonal sensitivity, depression, and anxiety were significantly decreased. Those mental disorders were thought to be somehow connected with personal appearance. Some studies also reported the perception or life quality of PE patients,[18–20] which agreed with our results. In general, after the Nuss surgical procedure, mental health of PE patients was mostly improved.

Furthermore, we found that age and total suffering years had significant effect on the postoperative alleviation of mental disorders, whereas gender, education, marital status, HI, or the degree of surgical repair of deformity had no significant effect. It is suggested that the psychological state of PE patients generated with time, and thus could be hardly converted. A recent study had also observed that after the Nuss surgical procedure, younger PE patients performed more postoperative satisfaction than those older,[2] and many reports had

Table 4 Association between demographic characteristics and depressive status of the depressive pectus excavatum patients after surgery

Characteristics	Postoperative patients without depressive status, n (%)	Postoperative patients with depressive status, n (%)	p value
Age			
11–16	29 (37.66%)	14 (18.42%)	0.019
17–22	40 (51.95%)	47 (61.84%)	
≥23	8 (10.39%)	15 (19.74%)	
Gender			
Male	67 (84.21%)	64 (84.21%)	0.792
Female	10 (15.79%)	12 (15.79%)	
Education			
≤Junior middle school	22 (28.57%)	14 (18.42%)	0.133
Senior middle school	30 (38.96%)	26 (34.21%)	
≥College	25 (32.47%)	36 (47.37%)	
Marital status			
Unmarried	74 (96.10%)	74 (97.37%)	0.988
Married	3 (3.90%)	2 (2.63%)	
	Postoperative patients without depressive status (n = 77)	Postoperative patients with depressive status (n = 76)	p value
PE status*			
HI	4.19 ± 1.12	4.28 ± 1.17	0.923
Suffering year	8.52 ± 5.82	11.17 ± 7.22	0.006
Resting platelet Aggregation: area under the curve*	150.4 ± 15.8	183.8 ± 37.4	0.005
Epinephrine 10 μm	265.1 ± 19.2	277.5 ± 31.9	0.312
Collagen 10 μm	251.7 ± 16.8	243.3 ± 27.2	0.678
ADP 5 μm	7.8 ± 2.5	12.2 ± 4.2	0.012
5HT 10 μm	229.3 ± 20.8	245.7 ± 43.3	0.421
5HT 10 μm + epinephrine 10 μm	256.2 ± 27.1	274.8 ± 35.0	0.298
5HT 10 μm + collagen 2 μm	238.8 ± 15.5	230.1 ± 41.7	0.702
5HT 10 μm + ADP 1 μm			

*Data given as mean ± SD. ADP: adenosine diphosphate; 5HT: serotonin; HI: Haller index; PE: pectus excavatum

unfolded the close relationship between the satisfaction of patients and postoperative psychosocial status.[21–23] Along with our results, we suggested that the Nuss surgical procedure for PE should be done at a younger age, as the psychological state of older patients could have been generally formed. Yet, if the age is too young, the surgery may result in operation failure or recurrence, since the non-stop bone growth. Thus, the time window for surgery is still in doubt and may vary with differed body state. Generally speaking, patients at puberty have very low recurrence after PE surgery. So it is an advisable suggestion to do the surgery at puberty. Indeed, additional psychological treatment and intervention for the teenagers could help improved the quality of life better.

In our study, we also found that postoperative patients with depressive status had a higher platelet aggregation response to two neurotransmitters 5HT and epinephrine, but not ADP or collagen. Since the well-known 5HT system has been implicated in the pathogenesis of major depressive disorder,[24] the platelet reactivity might be involved in the depressive status of PE patients.[25] Thus, we suggest an early detection of platelet reactivity in PE patients.

Conclusion

PE patients do have mental health problems such as depression and social dysfunction which may result from their appearance, and after surgical correction, those mental problems were significantly alleviated. Furthermore, it is necessary to get surgery at a younger age around puberty.

Disclosure Statement

All the authors have declared that there is no conflict interest.

References

1) Molik KA, Engum SA, Rescorla FJ, et al. Pectus excavatum repair: experience with standard and minimal invasive techniques. J Pediatr Surg 2001; **36**: 324-8.
2) Kuru P, Cakiroglu A, Er A, et al. Pectus excavatum and pectus carinatum: associated conditions, family history, and postoperative patient satisfaction. Korean J Thorac Cardiovasc Surg 2016; **49**: 29-34.
3) Ji Y, Liu W, Chen S, et al. Assessment of psychosocial functioning and its risk factors in children with pectus excavatum. Health Qual Life Outcomes 2011; **9**: 28.
4) Guo L, Mei J, Ding F, et al. Modified Nuss procedure in the treatment of recurrent pectus excavatum after open repair. Interact Cardiovasc Thorac Surg 2013; **17**: 258-62.
5) Roberts J, Hayashi A, Anderson JO, et al. Quality of life of patients who have undergone the Nuss procedure for pectus excavatum: Preliminary findings. J Pediatr Surg 2003; **38**: 779-83.
6) Lawson ML, Cash TF, Akers R, et al. A pilot study of the impact of surgical repair on disease-specific quality of life among patients with pectus excavatum. J Pediatr Surg 2003; **38**: 916-8.
7) Krasopoulos G, Dusmet M, Ladas G, et al. Nuss procedure improves the quality of life in young male adults with pectus excavatum deformity. Eur J Cardiothorac Surg 2006; **29**: 1-5.
8) Lam MW, Klassen AF, Montgomery CJ, et al. Quality-of-life outcomes after surgical correction of pectus excavatum: a comparison of the Ravitch and Nuss procedures. J Pediatr Surg 2008; **43**: 819-25.
9) Kelly RE, Cash TF, Shamberger RC, et al. Surgical repair of pectus excavatum markedly improves body image and perceived ability for physical activity: multicenter study. Pediatrics 2008; **122**: 1218-22.
10) Jacobsen EB, Thastum M, Jeppesen JH, et al. Health-related quality of life in children and adolescents undergoing surgery for pectus excavatum. Eur J Pediatr Surg 2010; **20**: 85-91.
11) Schmitz N, Hartkamp N, Kiuse J, et al. The Symptom Check-List-90-R (SCL-90-R): a German validation study. Qual Life Res 2000; **9**: 185-93.
12) Xu W, Li M, Yao J. Intervention of collective exercise on the mental health of elderly hypertensive patients. Iran J Public Health 2016; B: 314-21.
13) Zung WW. A self-rating depression scale. Arch Gen Psychiatry 1965; **12**: 63-70.
14) Berger JS, Becker RC, Kuhn C, et al. Hyperreactive platelet phenotypes: relationship to altered serotonin transporter number, transport kinetics and intrinsic response to adrenergic co-stimulation. Thromb Haemost 2013; **109**: 85-92.
15) Zou X, Lin Y, Jin H, et al. Screening for pectus excavatum among primary students and establishment of a pectus excavatum screening program in Dongguan, China. J Thorac Dis 2015; **7**: 868-74.
16) Singh VP, Moss TP. Psychological impact of visible differences in patients with congenital craniofacial anomalies. Prog Orthod 2015; **16**: 5.
17) Xu X, Shen B, Zhang A, et al. Anxiety and depression correlate with disease and quality-of-life parameters in Chinese patients with ankylosing spondylitis. Patient Prefer Adherence 2016; **10**: 879-85.
18) Kelly RE. Pectus excavatum: historical background, clinical picture, preoperative evaluation and criteria for operation. Semin Pediatr Surg 2008; **17**: 181-93.
19) Krille S, Muller A, Steinmann C, et al. Self- and social perception of physical appearance in chest wall deformity. Body Image 2012; **9**: 246-52.
20) Knudsen MV, Grosen K, Pilegaard HK, et al. Surgical correction of pectus carinatum improves perceived body image, mental health and self-esteem. J Pediatr Surg 2015; **50**: 1472-6.
21) Pérez-San-Gregorio MA, Fernández-Jiménez E, Martín-Rodríguez A, et al. Quality of life in women following various surgeries of body manipulation: organ transplantation, mastectomy, and breast reconstruction. J Clin Psychol Med Settings 2013; **20**: 373-82.
22) Adogwa O, Carr K, Fatemi P, et al. Psychosocial factors and surgical outcomes: are elderly depressed patients less satisfied with surgery? Spine (Phila Pa 1976) 2014; **39**: 1614-9.
23) Urban-Baeza A, Zárate-Kalfópulos B, Romero-Vargas S, et al. Influence of depression symptoms on patient expectations and clinical outcomes in the surgical management of spinal stenosis. J Neurosurg Spine 2015; **22**: 75-9.
24) Blier P, El Mansari M. Serotonin and beyond: therapeutics for major depression. Philos Trans R Soc Lond, B, Biol Sci 2013; **368**: 20120536.
25) von Kánel R. Platelet hyperactivity in clinical depression and the beneficial effect of antidepressant drug treatment: how strong is the evidence? Acta Psychiatr Scand 2004; **110**: 163-77.