Original Article

Improvement in Quality of Life of Pectus Excavatum Patients after Nuss Procedure

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Background: Pectus Excavatum (PE) is the most common anterior chest wall deformity. It is prevalent approximately 1:300 to 400 live births. In general, the patients with this deformity are doing well although the depression of the sternum is believed to compress the right ventricular outflow tract or to reduce lung volume. Majority of teenager and young adult patients, however, are concerned about their body image and even poor self-esteem. Nowadays, minimally invasive repair of pectus excavatum (MIRPE), so called Nuss procedure, is accepted as a standard treatment that offers less postoperative pain, safety and satisfactory outcome. Additionally, the procedure improves quality of life of the patients in terms of either physical or psychological aspect, determined by a specifically validated questionnaire.

Objective: To evaluate the improvement of quality of life in PE patients after MIRPE.

Materials and Methods: We collected data of 150 PE patients from January 2006 to December 2018. Informed consent was obtained from all patients before responding the Nuss questionnaire modified for adult pre- and postoperatively. A single-step-questionnaire was applied for postoperative evaluation of quality of life. Statistical analysis, paired t-test was used to compare patients' preoperative and postoperative quality of life.

Results: Among 150 patients, the average score of questionnaires was significantly increased from 2.99 (SD=0.52) preoperatively to 3.68 (SD=0.33) postoperatively (p-value <0.05). Self-esteem was improved from 7.03 (SD=1.75) to 8.74 (SD=0.91). Overall satisfaction score was 4.11 (SD=0.37).

Conclusion: Nuss procedure has improved the quality of life of the patients with pectus excavatum after surgery. However, further periodic follow-up must be exercised to determine long-term outcome as well as satisfaction after the removal of the Nuss bar.

Keywords: Quality of life; Pectus excavatum; Nuss procedure; MIRPE

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Pectus excavatum (PE) is the most prevalent anterior chest wall deformity, occurring as frequently as 1 in 300 to 400 live births. It occurs more frequently in boys than girls by an almost 4:1 ratio and rare in African race. Histopathologic features in costal cartilages are similar to those seen in scoliosis, aseptic osteonecrosis, and inflammatory process. This appears to cause overgrowth of the costal cartilages and depression of the sternum but the etiology of these findings and PE remains unknown[1]. This deformity may cause pain in the area of deformed cartilages, compress the right ventricular outflow tract and reduce lung volume that possibly cause cardiopulmonary problems. Cosmetic problems seem to cause the loss of self-esteem and affect social behavior[2]. Minimally invasive repair of pectus excavatum (MIRPE), so called Nuss procedure, has been developed using video-assisted, placement of metallic implant(s) to correct the PE, and does not require cartilage incision or resection offering the less invasive surgery. This procedure has shown improvement in quality of life[2,3].

The present study aims to compare quality of life of PE patients before and after undergoing MIRPE using Thai-translated Nuss Questionnaire modified for adults (NQ-mA) and single step questionnaire (SSQ).

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Materials and Methods

Patient selection

We collected data of 195 PE patients who underwent MIRPE in Ramathibodi hospital between January 2006 and December 2018 but 45 patients' medical records were missing due to loss to follow-up. All patients' medical records were collected at Ramathibodi Hospital, Mahidol university, Thailand. The proposal of the present study was approved by ethic committee of Faculty of Medicine, Ramathibodi Hospital, Mahidol university on 24 October 2017, EC No. MURA2017/576. Informed consent was obtained from each patient.

The clinical data including age, sex, associated

diseases, weight, height, presenting symptoms, pre-operative computerized tomography (CT) data e.g. Haller index, and complications were collected. Patients were asked to complete NQ-mA before surgery and 2 weeks after discharge and SSQ were responded at the same time at follow-up clinic.

CT data

The Haller index or pectus index is calculated by dividing the transverse diameter of the chest by the anterior-posterior distance on CT of the chest on the axial slice that demonstrates the shortest distance between the anterior surface of the vertebral body and the posterior surface of the sternum[4].

Questionnaires

Nuss Questionnaire modified for adult is disease-specific quality of life assessment tool that was modified by Krasopoulos[2] from Nuss questionnaires, first published by Lawson[5]. To minimize the recall bias, we analyzed NQ-mA only for patient underwent Nuss procedure after the proposal of this research has been approved. The SSQ was developed and validated[2]. It was simple and reliable and we analyzed the SSQ in all patients.

Statistical analysis

Statistical analysis of the demographic data was performed using mean±standard deviation and median (inter-quartile range). Patient characteristics were compared in terms of score NQ-mA questionnaires of pre- and post-operation using Wilcoxon signed-rank test for continuous variables, and SSQ questionnaires score. Nevertheless the SSQ consisted of questions regarding comparison between pre and post operation (item 3, 4 and 8, 9). All statistical analysis were performed with Stata v.14 (StataCorp LP). Statistics were significant with p-value less than 0.05.

Results

Medical records of 195 patients with pectus excavatum were enrolled, but 45 records were excluded because of incomplete data. 117 of 150 (78%) patients were male whereas 33 patients (22%) were female. Average age of patients was 16 years (median 15, IQR 5, 34). Most of patients were asymptomatic (58%) while second most common symptom was dyspnea (39%). Regarding pre-operative computerized tomography (CT) data, lung bullae were demonstrated in 3 per cent of the patients. The median of Haller index was 4.37, (IQR 2.42, 14). Almost half of the patients had mild sternal depression index. All patients' demographic and clinical data were demonstrated in Table 1.

Concerning the postoperative course, median length of hospital stay was 4 days (IQR 2, 36). Overall prevalence of postoperative complications was one-forth. The most common postoperative complication was pneumothorax (23%). Only one case was managed using simple aspiration while other cases could be treated conservatively and the pneumothorax was resolved by time. There were two patients requiring re-operation as a result of bar displacement. One of them had Haller index of 9 but the other's Haller index was 6. One patient had wound seroma treated using needle aspiration.

In order to prevent the recall bias, we selected the data of patients who underwent the operation while we conducted this study. The results of questionnaires were shown in Table 2 and Table 3. The NQ-mA was categorized into psychological (item 1 to 9) and physical aspect (item 10 to 12). The median scores were analyzed for each question and showed that there were statistically significant improvement after the operation (p=0.000). The score from SSQ revealed that Nuss procedure was satisfied by the patients (item 14-median score = 4). The improvement of self-esteem was also increased significantly from 8 to 9 (item 8 to 9), p=0.000. Nearly all patients (98.65%) considered that they had made the right decision to do the surgery. Distribution of median score of each question obtained from NQ-mA and SSQ was demonstrated in Figure 3.

Discussion

In the present study, we found that Nuss procedure had good short-term outcome either physical or psychological aspects, and low complication rate. Only two patients needed re-operation due to bar displacement which from extremely high Haller index. Another complication was pneumothorax which can be resolved by conservative treatment. The physical and psychological aspects from Nuss questionnaires modified for adults scores showed significant improvement after surgery also the score from Single step questionnaires had the same result, increased self-esteem and overall satisfaction after the surgery. The degree of post-operative pain (during hospital stay) was severe according to the SSQ. Similarly, the report by Lawson et al[5] using child pectus excavatum evaluation questionnaires and parent pectus excavatum evaluation questionnaires by telephone interview on 22 parents and 19 children before and after underwent Nuss procedure showed the positive impact on both the physical and psychological well-being of the children. Goldstraw et al[2] had conducted the study of 20 male patients, with median age of 18 years by using both SSQ and NQ, and confirmed that Nuss procedure had a similar positive impact in young male adults and SSQ was an easy to use tool to evaluate quality of life and overall satisfaction of the patients. Sacco Casamassima et al[6] studied 98 adult patients undergoing Nuss procedure, and concluded that favorable long-term outcomes could be found with Nuss procedure in adults (89.7% satisfaction with chest appearance). However the complication was not similar to our study such as they encountered intra-operative pulseless ventricular arrhythmia and post operative pulmonary embolism, which had unclear related factors. Pinar Kuru et al[3] evaluated 88 patients, average age 18.44 years, by using NQ-mA pre-operatively and 6 months after the operation showed that Nuss procedure improved both physical and psychological well-being of the patients. Kang et al[7] studied 100 pectus excavatum patients who underwent both Nuss and Ravitch procedures. The

Table 1. Demographic and characteristic data of patients

Characteristics data	n (%)	Median (range)
Gender		
Male	117 (78.00)	
Female	33 (22.00)	
Age (year)		15 (5, 34)
Weight (kg)		49 (17, 76)
High (cm)		168 (105, 187)
BMI		17.11 (11.16, 33.56)
Associations disease		
Marfan's syndrome	2 (1.33)	
Scoliosis	9 (6.00)	
Asthma	4 (2.67)	
Others	9 (6.00)	
Preoperative symptoms		
Asymptomatic	87 (58.00)	
Dyspnea	59 (39.33)	
Pain	2 (1.33)	
Preoperative CT data		
Bullae		
No	113 (97.41)	
Yes	3 (2.59)	
Max length of chest wall		23.7 (15.7, 28.4)
Narrowest of width of chest wall		5.3 (1.4, 9.4)
Scoliosis degree		0 (0, 32)
Haller index		4.37 (2.42, 14.0)
Asymmetry index		1.03 (0.72, 1.80)
Flatness index		1.80 (1.0, 2.49)
Sternal torsion angle		18 (-37, 45)
Angel of Louis		170 (149, 196)
Cardiac rotation angle		56 (36, 86)
Sternal depress index		2.4 (1.58, 6.7)
Mild <2.4	56 (49.12)	
Moderate 2.4 to 2.9	32 (28.07)	
Severe >2.9	26 (22.81)	
Length of stay (day):		4 (2, 36)
Number of bar		
I	135 (93.10)	
II	10 (6.90)	
Complication		
Pneumothorax	35 (23.33)	
Bar displacement	2 (1.33)	
Would seroma	1 (0.67)	
Pleural effusion	1 (0.67)	
Re-op	3 (2.00)	

Table 2. Results of Nuss Questionnaire modified for adults (NQ-mA), psychological (item 1 to 9) and physical aspect (item 10 to 12)

NQ-mA	Score (pre)	Score (post)	Pre-post
	Median (IQR)	Median (IQR)	p-value
Psychological			
1) Overall shape	2 (0)	3 (0)	0.000
2) The shape of the chest when not wearing a shirt.	2 (1)	3 (0)	0.000
3) If you continue to have this shape of your chest for the rest of your life	1 (1)	3 (0)	0.000
4) Being teased by other people about the shape of the chest	3 (1)	4 (1)	0.000
5) Must avoid doing various activities	2 (1)	3 (1)	0.000
6) You have to cover your chest.	2 (1)	4 (1)	0.000
7) Being bullied because of the shape of the chest.	4 (0)	4 (0)	0.000
8) Being embarrassed or lacking in confidence because of the shape of the chest.	2 (2)	4 (1)	0.000
9) You feel bad.	4 (1)	4 (0)	0.000
Physical			
10) There is a problem with exercise.	3 (1)	4 (1)	0.000
11) The shape of the chest makes it difficult to breathe.	4 (1)	4 (0)	0.000
12) The shape of the chest makes you tired.	4 (1)	4 (0)	0.000

Table 3. Results of single step questionnaire (SSQ)

Single Step Questionnaires (SSQ)	Score (post), median (IQR)
1) Overall health after surgery.	4 (0)
2) Ability to exercise after surgery.	4 (1)
3) The shape of the chest before surgery affects socialization.	3 (1)
4) The shape of the chest after surgery affects socialization.	4 (1)
P-value compare between item 3 and 4	0.000
5) Overall satisfaction after surgery.	4 (1)
6) The scar of the surgery bothers you.	4 (1)
7) This surgery affects your socialization.	4 (1)
8) Self-esteem before surgery (1 least to 10 the most).	8 (2)
9) Self-esteem after surgery (1 least to 10 the most).	9 (2)
P-value compare between item 8 and 9	0.000
10) Pain during hospitalization.	2 (1)
11) Pain after surgery affects daily life.	3 (1)
12) Pain while answering this questionnaire.	4 (1)
13) You can feel the feeling of metal being put in your body.	3.5 (1)
14) Overall satisfaction in the end result.	4 (1)
15) The shape of the chest has changed in the way you want.	4 (1)
16) If you could go back, you will still decide to have surgery.	146 (98.65%)*

* 146 patients answered "Yes"

satisfaction was evaluated by questionnaires demonstrated that 60 of 79 patients were satisfied. Kelly et al[8] also reviewed the outcome of Nuss procedure and confirmed that the procedure showed significant outcomes on patients' self-

Question stem	Scoring
1. Looks in general	1: Very unhappy, 2: mostly unhappy, 3: mostly happy, 4: very happy
2. How chest looks without shirt	1: Very unhappy, 2: mostly unhappy, 3: mostly happy, 4: very happy
3. Spending rest of life as chest looks now	1: Very unhappy, 2: mostly unhappy, 3: mostly happy, 4: very happy
4. Others make fun of him/her because of chest	1: Very often, 2: often, 3: sometimes, 4: never
5. Avoids doing things	1: Very often, 2: often, 3: sometimes, 4: never
6. Hides chest	1: Very often, 2: often, 3: sometimes, 4: never
7. Bothered because of the way chest looks	1: Very often, 2: often, 3: sometimes, 4: never
8. Feels shy/self-conscious because of chest	1: Very often, 2: often, 3: sometimes, 4: never
9. Feels bad about self	1: Very often, 2: often, 3: sometimes, 4: never
10. Has trouble exercising	1: Very often, 2: often, 3: sometimes, 4: never
11. Chest causes shortness of breath	1: Very often, 2: often, 3: sometimes, 4: never
12. Chest causes him/her to be tired	1: Very often, 2: often, 3: sometimes, 4: never

Figure 1. Nuss Questionnaires modified for Adult, Reference: (3).

Question stem	Scoring
1. Health in general after the operation	Much better now: 5, Somewhat better: 4, About the same: 3, Somewhat worse now: 2, Much worse now: 1
2. Exercise capacity after the operation	Much better now: 5, Somewhat better: 4, About the same: 3, Somewhat worse now: 2, Much worse now: 1
3. Extent that chest looks interfere with pre-operative social activity	Extremely: 5, Quite a bit: 4, Moderately: 3, Slightly: 2, Not at all: 1
4. Extent that chest looks interfere with post-operative social activity	Not at all: 5, Slightly: 4, Moderately: 3, Quite a bit: 2, Extremely: 1
5. Satisfaction with the overall post-operative appearance	Extremely satisfied: 5, Very satisfied: 4, Satisfied: 3, Dissatisfied: 2, Very dissatisfied: 1
6. Bothered by the surgical scars	Not at all: 5, Very slightly: 4, Slightly: 3, A little bit: 2, A lot: 1
7. Impact operation had to social life	Major improvement: 5, Improved: 4, No change: 3, Worse now: 2, A lot worse now: 1
8. Pre-operative self-esteem	Score: 1–10
9. Post-operative self-esteem	Score: 1–10
10. Pain during hospital stay	None: 5, Very mild: 4, Mild: 3, Moderate: 2, Severe: 2, Very severe: 1
11. Pain interfering with day-to-day activity now (5 months post-operatively)	Not at all: 5, Very slightly: 4, Slightly: 3, A little bit: 2, A lot: 1
12. Pain now (5 months post-operative)	No: 5, Occasionally: 4, Mild—no painkillers: 3, Mild—painkillers: 2, A lot: 1
13. Conscious about the metallic bar	Not at all: 5, Slightly: 4, Moderately: 3, Quite a bit: 2, Extremely: 1
14. Overall satisfaction with the final result	Extremely satisfied: 5, Very satisfied: 4, Satisfied: 3, Dissatisfied: 2, Very dissatisfied: 1
15. Chest looks different	Major improvement: 5, Improved: 4, No change: 3, Worse now: 2, A lot worse now: 1
16. Going back, would you have the operation again	Yes: 10, Un-sure: 5, No: 0

Figure 2. Single step Questionnaires, Reference: (2).

perception and quality of life in terms of physical and psychological benefit. Unlike Jeong et al[9], we did not evaluate the pulmonary function before and after the surgery. Nevertheless from the questionnaires, the dyspnea symptom seemed to be improved after the surgery.

The limitation of the present study was retrospective in nature which had the recall bias and incomplete collection of medical records. The pre- and post-operative pulmonary function test and echocardiography data were missing in the majority of cases. Longitudinal observation was needed to confirm long-term results. Improvement of the outcomes after bar removal was also necessary to be studied. Additional parameters such as pre-operative CT data could be used to study the correlation amongst the outcome variables especially the degree of pain, satisfaction, and complications.

Conclusion

In conclusion, Nuss procedure is a safe and effective procedure. It has improved the quality of life of the pectus excavatum patients after surgery. However, further long-term follow-up must be exercised to determine long-term outcome as well as satisfaction after the removal of the Nuss bar.

What is already known on this topic?

Aesthetic results have been confirmed by previous studies. Several studies also demonstrated

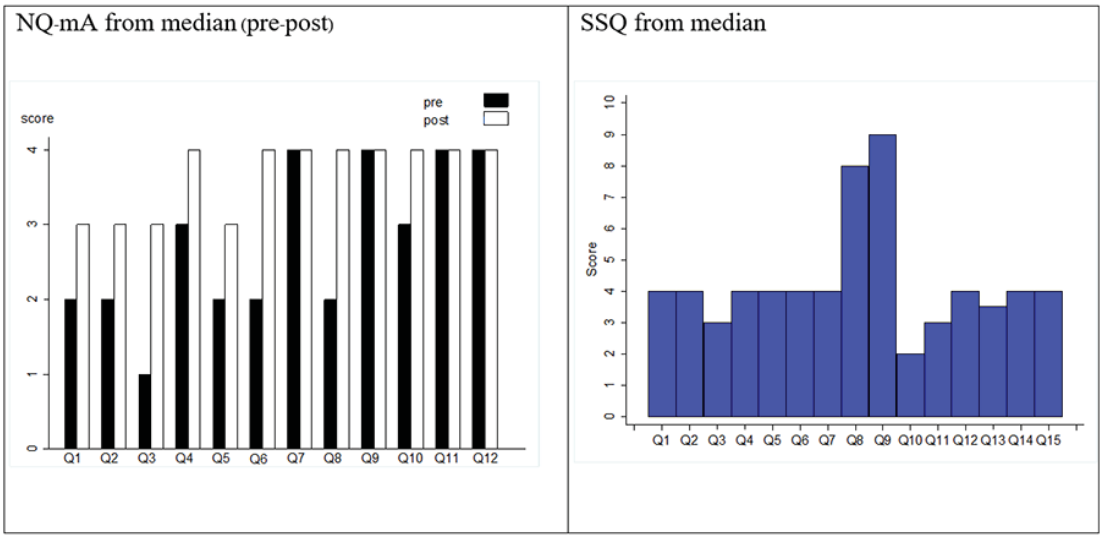

Figure 3. Distribution of median score of each question obtained from NQ-mA and SSQ.

physiological benefits of minimally invasive repair for pectus excavatum (MIRPE). However, there have been limited literature emphasising quality of life per se after the Nuss procedure.

What this study adds?

This is the first and largest series of corrected pectus excavatum in Thailand focusing on quality of life of repaired pectus excavatum either postoperative period and after removal of the Nuss bar. This study complements the physiological benefits and psychological outcome.

Potential conflicts of interest

The authors declare no conflict of interest.

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