AN EFFECT OF NUSS PROCEDURE ON LUNG FUNCTION AMONG PATIENTS WITH PECTUS EXCAVATUM

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The aim of the study was to evaluate lung function among patients who underwent Nuss Procedure. The analysis included spirometric evaluation of the lung function before Nuss Procedure, during perioperative period and after removing steel bars from behind the sternum.

Material and methods. The study group involved patients operated on the pectus excavatum in the Department of Thoracic Surgery in Poznań in years 2002-2004. The study group consisted of 44 patients (5 females and 39 males). Aged between 10 to 32 years old, the mean age was 16. The following spirometric parameters were analysed: vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1s (FEV1), FEV1/VC ratio, peak expiratory flow (PEF), forced expiratory flow for 25% (FEF25), 50% (FEF50) and 75% FVC (FEF75).

Results. The values of the FVC, FEV1, FEF25, and FEV1/VC ratio in the study group were significantly higher in the postoperative period in comparison with the preoperative period. There was a statistically significant correlation between the improvement in spirometric parameters after Nuss Procedure and the impairment of spirometric values in preoperative period. There were no statistical differences between the value of initial chest deformation and spirometric parameters improvement. There were also no statistically significant correlations between age, height and weight of the patient in the study group and spirometric values improvement.

Conclusion. There is a statistical improvement in lung function in patients who underwent Nuss Procedure. The improvement in spirometric parameters correlates with the impairment of spirometric values in the preoperative period.

Key words: funnel chest, koilosternia, pectus excavatum, Nuss Procedure

A method of the surgical treatment of pectum excavatum was published by Nuss in 1998 basing on 10-year follow-up of a group of 42 children who underwent surgical treatment (1). It was quickly accepted by patients and surgeons due to its low invasive nature and very good treatment results. It also was successfully adopted to the treatment of adult patients.

However, clinical improvement with regard to cardiovascular and respiratory system function was inadequately documented in objective studies. Previously effects of Ravitsch corrective surgery of pectum excavatum, a dominant treatment method in the second half of the 20th century, was studied. Obtained results were equivocal with regard to respiratory system function (2-5). However, studies of effects of surgical treatment of pectum excavatum using Nuss Procedure were relatively limited (6, 7, 8). Vast majority of patients is satisfied with
obtained results both with regard to aesthetic and functional effects. The experience clinical improvement with regard to exercise capacity, in particular ability to perform long-term exercise. However, objective studies that attempted to objectively assess this improvement, were limited. The most important assessment is done after completion of the whole treatment, i.e. after removal of steel bars from behind the sternum.

Examination of respiratory system function is very important due to the persisting belief that this defect is only of “cosmetic” nature. The ability to improve respiratory system function is an additional qualifying criterion to surgical treatment. It is also of importance if results with such regard obtained using the Nuss Procedure is better than obtained with Ravitsch Procedure.

The aim of this study is to assess respiratory system function basing on spirometric tests in patients with pectus excavatum who underwent the Nuss Procedure.

**MATERIAL AND METHODS**

The study group included 44 patients who underwent surgical treatment for pectus excavatum at the Department of Thoracic Surgery, Poznań University of Medical Sciences between 2002 and 2004. The group included 5 females (11.4%) and 39 males (88.6%). Age of the study subjects ranged from 10 to 32 years (average 16 years). All study subjects underwent the Nuss Procedure.

Spirometric tests were performed three times: before the procedure, in the interoperative period and after removal of steel bars from behind the sternum. The interval between first and second operation was 2-3 years.

The following spirometric parameters were analysed: vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1s (FEV1), FEV1/VC ratio, peak expiratory flow (PEF), forced expiratory flow for 25% (FEF25), 50% (FEF50) and 75% FVC (FEF75). The obtained results were referred to patient’s age, body weight and height and were expressed as per cent of predicted values. Degree of chest deformation was assessed using radiographic methods (chest X-ray) and cavity, maximum and minimum depth, chest width and Król and Haller indices were assessed.

Obtained results were subjected to statistical analysis using STATISTICA 7.0 and GraphPad software. Normality of distribution of the variables was verified using Shapiro-Wilk test. Mean, standard deviation and median were calculated. Significance of difference for paired samples was assessed using Friedman method and multiple comparison Dunn procedure. Spearman correlation index was calculated. Result of each statistical test was considered significant if the significance level was below 0.05 (p < 0.05).

**RESULTS**

A statistically significantly higher level of FVC (fig. 1), FEV1 (fig. 2), FEF25 and FEV1/
VC ratio (fig. 3) in the postoperative period was found versus the preoperative period.

A negative linear correlation between baseline and final spirometric parameters was also found (fig. 4).

No statistically significant correlation was found between degree of baseline deformation (cavity, maximum and minimum depth, chest width and Król and Haller indices) and improvement of spirometric parameters. Furthermore, no statistically significant correlation was found between baseline age, body weight, and height and degree of improvement of spirometric parameters.

No severe postoperative complications were observed. Postoperative pneumothorax was found in twelve of the patients who underwent the surgical procedure; only in two patients it required surgical drainage. It underwent spontaneous desorption in the remaining subjects.

**DISCUSSION**

The essence of pectus excavatum is depression of the sternum with adjacent parts of the ribs, mainly in its lower part. It reduces the retrosternal space and modifies position of the heart through its leftward displacement, rotation and compression. Shape of the chest and type of respiration are also changed. Upon inspiration the funnel-shaped part of the sternum retracts even further.

Surgical treatment of funnel-shaped chest started at the beginning of the previous century (Sauerbruch, 1913). Ravitsch Procedure with its multiple modifications was the “gold standard” treatment in the second half of the 20th century. Preoperative assessment demonstrates reduction of multiple parameters of respiratory system, including mainly FEV1, VC, PEF. Conducted tests of respiratory system did not provide any clear answer regarding effect of the Ravitsch Procedure on lung function. Favorable effect was reported for pronounced deformations, while mild or none improvement for mild defects (9, 10). This supported the widespread opinion that the surgery has only cosmetic effects. However, this contradicts clinical observations in patients who underwent surgical treatment. Before the surgical treatment, many of them complain of impaired exercise capacity, mainly as compared to their peers. Some of them also complain of increased incidence of respiratory infections, some present with asthmatic symptoms. Improvement of resolution of these symptoms is observed after the surgical treatment. Improvement of cardiovascular system partially accounts for this. The heart, compressed by retracted sternum, is displaced to the left, flattened and rotated. After the corrective procedure it can return to its more normal position. Multiple studies and metaanalysis dated 2006 clearly proved beneficial effect of surgical treatment on the cardiovascular system (11). However, preoperative assessment of respiratory system indicates restrictive disorder in spirometric testing, which also must affect exercise capacity.

In 1998 Donald Nuss published a paper demonstrating a new method of treatment of the funnel-shaped chests. It involves insertion of a U-shaped plate behind the sternum and
its rotation by 180 degrees. This results in immediate and sustained correction of the defect. This method avoids subchondral rib resection as in the Ravitsch Procedure that could have resulted in secondary postoperative restriction (12). This different concept of surgical treatment, involving sparing the existing structures, in theory should result in better postoperative outcome with regard to respiratory system function. However, such studies with patients who underwent the Nuss Procedure, were limited. It is very interesting since this method was widely accepted by both surgeons and patients due to the low-invasive nature of the procedure (small scars), very good esthetic outcome (perfect correction of the defect) and durability of the effect.

Studies conducted immediately after the surgical procedure may provide unclear results with regard to effect of the procedure on respiratory system function. Insertion of a corrective plate (one or two plates) creates an additional factor contributing to restriction of the chest wall. Metal plates do not change their length with respiratory movements and constitute a mechanical restriction to the chest respiratory efficacy. Furthermore, they do not elongate with growth of the patient in view of the fact that we maintain plates for 2 to 4 years. After removal of the plates, normal shape of the chest is restored without damage to the ribs. Therefore we could expect respiratory efficiency to be improved after their removal. Studies conducted in the group of 44 subjects confirmed reduction of some spirometric parameters such as FVC, FEV1, FEF25 (that were slightly below the predicted values). After the surgical treatment, all of them were improved. Spirometric vital capacity (VC) tested before the Nuss Procedure was low normal. After removal of the plates it tended to increase, but this was not statistically significant (p = 0.01).

Insertion of metal plates did not result in statistically significant improvement which suggested that the plates partially restricted respiratory efficiency of the chest wall, both with regard to lung volume and restriction. Statistically significant improvement between the period with platelets and after their removal supports this finding. However, the extent of final improvement versus the preoperative status (p < 0.05) supports effectiveness of the surgical procedure in the improvement of efficiency of the respiratory system. More important, the extent of the improvement increases with degree of preoperative impairment of lung function. This applies to VC, FVC, FEV1, and PEF.

This improvement did not correlate with degree of deformation. This can be explained by the fact that the radiographic deformation index is inadequate to assess the extent of the deformation or impairment of function is related to other significant factors, such as for example degree of training. Maybe more advanced imaging modalities, such as computed tomography, will result in statistically significant correlation between the baseline degree of deformation and improvement of spirometric values.

Obtained improvement did not correlate with the patient’s age or body weight. This indicates that the Nuss procedure is equally effective in the elderly patients, and not only in young subjects with elastic chest. This indicates that the Nuss Procedure is more effective for patients as the surgical treatment of the chest, not only from the esthetic point of view, but also with regard to improvement of function of the respiratory system.

CONCLUSIONS

1. A significant improvement of function of respiratory system was found after the corrective treatment of the chest using the Nuss Procedure.
2. Obtained improvement does not depend on patient’s age or body weight or degree of chest deformation.
3. Improvement of spirometric parameters increases with degree of preoperative chest deformation.

REFERENCES

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