



## Correlation of asymmetric chest wall deformity and growth in patients with pectus excavatum

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### Abstract

**Purpose:** Pectus excavatum involves wide range of chest wall depression. The degree of depression or asymmetry varies between young and adolescent patients. It has not been clear how the deformity progresses as patients grow. To elucidate the change of asymmetric deformity, preoperative computed tomography (CT) scan was evaluated according to different age groups.

**Methods:** Preoperative CT scans of 154 patients with pectus excavatum were collected and analyzed using Haller's CT index, asymmetric index and sternal rotation angle. Patients were divided into 5 age groups as follows; group 1: 4–6 y (n=53), group 2: 7–9 y (n=25), group 3: 10–12 y (n=25), group 4: 13–15 y (n=23), group 5: 16–23 y (n=28). The degree of asymmetric chest wall deformity was expressed using sternal rotation angle as follows; symmetrical ( $-5^\circ$  to  $+5^\circ$ ), left-mild ( $-5^\circ$  to  $-15^\circ$ ), right-mild ( $+5^\circ$  to  $+15^\circ$ ), right-moderate ( $+15^\circ$  to  $+25^\circ$ ) and right-severe (over  $+25^\circ$ ).

**Results:** As the age of patients increased, asymmetric index increased from  $1.025 \pm 0.065$  in group 1 to  $1.124 \pm 0.111$  in group 5 and sternal rotation angle also increased from  $6.11 \pm 8.61$  in group 1 to  $15.41 \pm 11.98$  in group 5. In these two parameters, significant difference was seen between group 1 and 4, group 2 and 4, group 1 and 5 and group 2 and 5. However, average CT index revealed no significant difference in any age groups. In group 1, 83% of patients were classified in symmetrical or left- and right-mild. The incidence of right-moderate plus right-severe was 17% in group 1, 20% in group 2, 40% in group 3, 52.1% in group 4 and 50% in group 5.

**Conclusions:** The degree of chest depression did not show any change in all age groups. Asymmetric deformity on the right side progressed around the age of 10 to 12. Half of patients over the age of 13 showed moderate or severe asymmetry. These results were suggestive to consider the optimum age for the correction of pectus excavatum.

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Pectus excavatum is the most common chest wall anomaly and it affects 1 in 400 births [1]. It is characterized by a depression of the anterior chest wall. However, each case of pectus excavatum has different chest morphology. Classifi-

cation of the morphology of pectus excavatum has been proposed [2–4]. Among various classifications, basic type of the deformity is symmetric depression and asymmetric depression [3]. This classification is important for a surgical point of view. Because, operative correction of asymmetric cases was difficult and the results were not always satisfactory from our experience with more than 650 cases.

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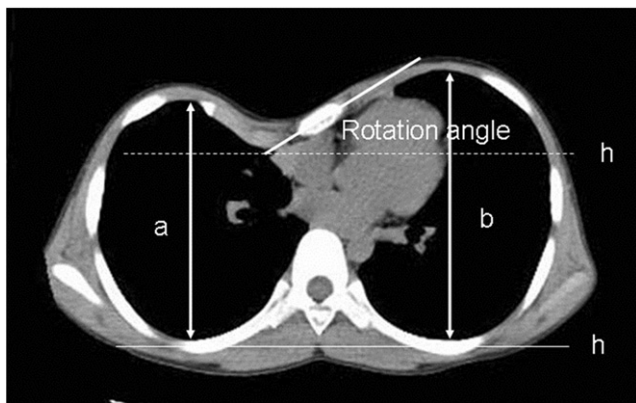
Asymmetric cases are more prevalent in adults than in young patients [5]. It has been postulated that pectus excavatum is a progressive disease. However, it is not well known about the development of the morphologic change during growing. The purpose of this study is to clarify how the morphological change of the chest wall develops from young age to adults. To study the change of chest wall deformity, preoperative CT scan of patients with pectus excavatum in different age groups was examined and Haller's CT index, sternal rotation angle and asymmetric index were analyzed.

There has been a discussion about the optimal age for the repair of pectus excavatum [5–8]. For the consideration of operative age, surgical results, recurrence and progression of the chest wall deformity have to be elucidated. On the basis of the study of progression of chest deformity, optimal age for surgical correction is discussed.

## 1. Materials and methods

All patients with pectus excavatum who underwent the Nuss procedure in our institution from November 2005 to September 2007 were retrospectively reviewed. During this period, we operated on 164 cases between the age of 4 and 23. Among them, 10 cases with redo operation or previous chest operation were excluded from this study. A total of 154 cases were included in the study and retrospective chart review was carried out. Patients were divided into 5 age groups as follows; group 1: 4–6 y (n=53), group 2: 7–9 y (n=25), group 3: 10–12 y (n=25), group 4: 13–15 y (n=23), group 5: 16–23 y (n=28).

Preoperative CT scans of 154 patients were collected and the Haller's CT index was measured. In addition, the most prominent sternal twist was selected in the CT scans and the sternal rotation angle against the horizontal line was measured (Fig. 1). Also, in the same film, asymmetric index was measured (Fig. 1). All radiological measurements were conducted on a



**Fig. 1** Demonstration of measurements using ImageJ on computer. Asymmetric index calculated by  $b/a$  and sternal rotation angle measured against a horizontal line (h) are shown in the figure. This CT of 12-y-old patient exhibited +24.9 degree of rotation angle (right-moderate) and 1.176 of asymmetric index.

computer using image analyzer software (Image J: a public domain Java image processing program, Bethesda, USA).

To investigate the degree of asymmetric deformity in different age groups, sternal rotation angle was used. Patients were divided into 5 groups according to the degree of the sternal rotation. Right side depression of the chest wall, which indicated anti-clock wise twist of the sternum was expressed as positive (Fig. 1). Sternal rotation angle between  $-5^\circ$  and  $+5^\circ$  was regarded as symmetrical. The severity of the sternal twist was divided in mild, moderate and severe in 10 degrees steps. Mild sternal twist to the left (sternal rotation angle between  $-5^\circ$  and  $-15^\circ$ ) was expressed as left-mild. Mild sternal twist to the right (sternal rotation angle between  $+5^\circ$  and  $+15^\circ$ ) was expressed as right-mild. Moderate ( $+15^\circ$  to  $+25^\circ$ ) and severe asymmetry (over  $+25^\circ$ ) on the right side was expressed as right-moderate and right-severe.

### 1.1. Statistical analysis

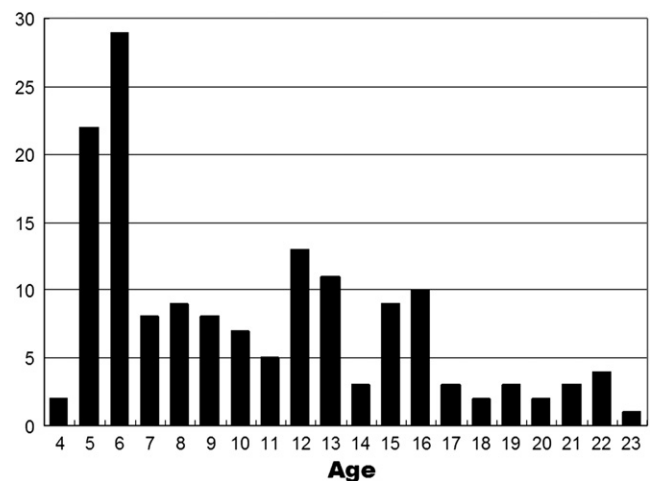
Correlation of asymmetry index and sternal rotation angle was analyzed. Multiple comparisons of asymmetric index, sternal rotation angle and CT index between 5 age groups were analyzed using non-repeated measures ANOVA test. In the groups which showed significant difference post hoc test using Sheffe's test was carried out.

### 1.2. Ethical committee

This study has obtained approval by the institutional review board in our university hospital. (IRB Assurance Number: 1109) There is no conflict of interest to be declared.

## 2. Results

Median age of 154 patients at the time of operation was 7 y old ranging from 4 to 23, and the average age was  $10.5 \pm 4.97$  y old. Age distribution of all cases was shown in Fig. 2.



**Fig. 2** Age distribution of 154 patients at the time of operation.

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