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Overgrowth of costal cartilage is not the etiology of pectus excavatum

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Abstract

Purpose: The etiology of pectus excavatum (PE) has not been clarified. In 1944, Sweet (Sweet RH. Pectus excavatum. *Ann Surg* 1944;119:922-934) mentioned about the possibility of the overgrowth of costal cartilage being involved. However, no additional report that supports his hypothesis is available. In this study, we investigated whether the overgrowth of costal cartilage was an actual cause of PE through measurement of the costal cartilage length in PE patients and healthy controls.

Materials and Methods: We investigated the length of the fifth and sixth costal cartilages and ribs in PE patients from reconstructed images of 3-dimensional computed tomography. To examine the relative costal cartilage length, we calculated the C/R ratio, defined as the quotient of the costal cartilage length divided by the adjacent rib length, and compared it between PE patients and healthy controls.

Results: In PE patients, the C/R ratios were not larger than in healthy controls at any level. At the left sixth, the C/R ratio was significantly smaller in patients than in the healthy control group.

Discussion: The results revealed that, in PE patients, relative costal cartilage lengths were not longer than in healthy controls. We conclude that the overgrowth of costal cartilage is not the etiology of PE.

Pectus excavatum (PE) is the most common anterior chest wall deformity. However, the etiology of PE has not still been clarified. Brown [1] described "the comparative elasticity and relative insecure fixation of the lower ribs might allow the diaphragm to pull the lower end of the sternum." The association between PE and other musculoskeletal abnormalities suggests that abnormal connective tissue plays a role.

On the other hand, Sweet [2] stated that "the substernal membrane or ligament did not appear to be a very important structure," and "it seems almost as though the sternum is pushed down against the spine by unusually long, inward curving costal cartilages." This is the origin of the overgrowth theory of PE. However, Sweet [2] did not measure the length of costal cartilage, but many pediatric surgeons have believed this overgrowth theory.

In our previous study [3], we reported that, in asymmetric PE patients, the right was shorter than the left rib, and the right costal cartilage was also short or did not differ from the left.

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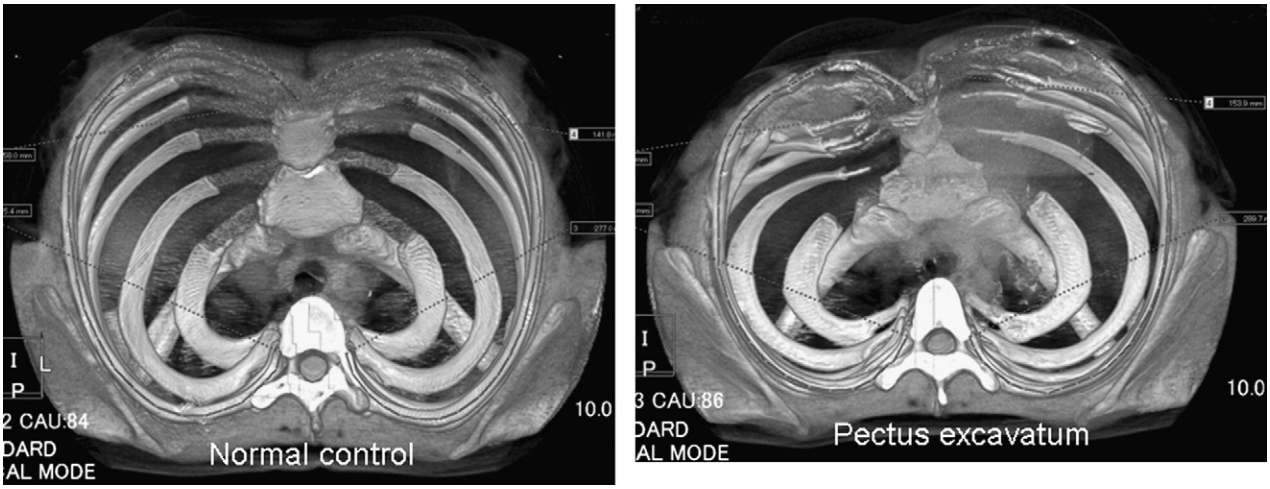

Fig. 1 Images of showing measurement procedure. A healthy control and PE patient are shown.

We investigated this theory through the measurement of costal cartilage in PE patients and healthy controls.

1. Subjects and methods

We enrolled 20 moderate to severe postpubertal PE patients in this study and 24 similarly aged healthy controls who received thoracic computed tomography to examine lesions ruling out thoracic deformities.

In both groups, we measured the lengths of the fifth and sixth ribs and costal cartilage using 3-dimensional computed tomography. The measurement method was described in our previous report [3] (Fig. 1).

In younger patients, costal cartilage is undergoing development. We wanted to examine fully developed cases of PE, and so we excluded younger patients from this study.

We defined the index C/R ratio, the quotient of the costal cartilage length divided by the adjacent rib length, to examine the relative costal cartilage length and compared it between the PE and control groups (Fig. 2).

Statistical analysis was conducted using with Mann-Whitney *U* tests or Fisher's Exact probability, and a *P* value of less than .05 was regarded as significant. This study was approved by the ethics committee of Kawasaki Medical School (Kurashiki, Okayama prefecture, Japan).

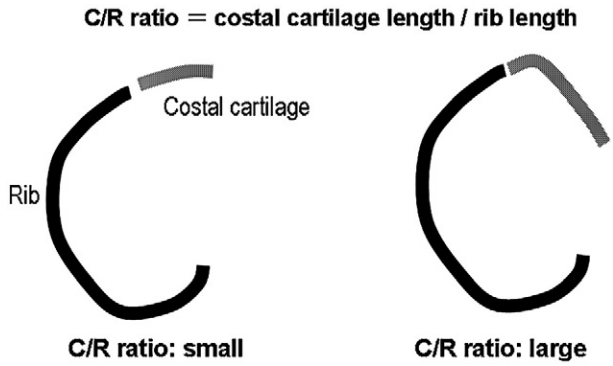

Fig. 2 This schema shows the C/R ratio. If the costal cartilage is too long, the C/R ratio would be large.

2. Results

The characteristics of patients and healthy controls are presented in Table 1. The male-female ratio and mean ages of both groups were not significantly different. The mean Haller's index [4] was 5.53 ± 2.25 in the PE group and 2.63 ± 0.38 in the healthy control group with a significant difference.

The mean C/R ratio of the left sixth was 0.29 ± 0.06 in the PE group and 0.33 ± 0.07 in the healthy control group, with a significant difference ($P = .04$). Mean C/R ratios of the left fifth, right fifth, and right sixth were also smaller in the PE group, but there was no significant difference (Figs. 3 and 4).

3. Discussion

In our previous report, we revealed that the ribs and costal cartilages on the right side with more severe depression were shorter than those on the contralateral side in asymmetric PE patients [3]. On the basis of these findings, we concluded that the costal cartilage was not the only factor responsible for

Table 1 Characteristics of patients

	Male-female ratio	Age	Haller's index
PE group	12:8	19.7 ± 3.88	5.53 ± 2.25 *
Healthy control group	18:6	18.3 ± 3.2	2.63 ± 0.38 *

* $P < .05$: calculated with the Mann-Whitney *U* test.