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Quantification of pectus excavatum: Anatomic indices

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ABSTRACT

Pectus excavatum is the most common chest wall deformity in children. The central portion of the chest is displaced posteriorly relative to the remainder of the anterior chest wall. Quantification of defect severity can be performed with multiple imaging modalities or external thoracic measures, but is most commonly quantified by the Haller Index (HI) or Pectus Correction Index (PCI). These two measures provide a measure of the chest based on cross sectional imaging, most commonly CT scans, allowing for standard comparison and definitions of pectus defects. The purpose of this article is to describe the creation, calculation, and limitations of the methods quantifying pectus defects.

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Introduction

Pectus excavatum is the most common chest wall deformity in children, with an incidence of 1 in 1000 children.[1] Pectus excavatum is a defect wherein the central chest is displaced posteriorly relative to the remainder of the anterior chest wall. Multiple measures[2–4] have been proposed to objectively quantify the degree of defect with the Haller Index and Pectus Correction Index (PCI) being the most widely used.

Haller index

One of the initial measures proposed, which was the clinical standard for the past few decades, was the Haller index (HI). Initially described in 1987, this metric was defined as the widest transverse diameter of the internal chest divided by the distance between the anterior spine and posterior sternum.[5] In general, the deep point at the bottom of the defect is chosen as the location to measure the denominator (Fig. 1). The value produced by the Haller Index indicates the ratio of the chest width to the deepest point of the sternal depression. The measurement is typically derived from computed tomography (CT) but some literature suggests chest x-rays (CXR) and magnetic resonance imaging (MRI) may also be utilized.[6–14] HI measured at different points in the respiratory cycle may skew the results.[15]

In its initial description, the authors set a width to depth ratio of 3.25 as the discriminator to define patients with a significant enough pectus excavatum defect to be a potential candidate for repair. This number was determined by comparing a group of normal controls to pectus excavatum patients who underwent repair. The authors found that the control patients had an index of <3.25 as opposed to the pectus patients. The decision to operate for pectus excavatum is also based on physical limitations secondary to the defect and psychosocial disposition but it's been a generally held belief that surgical candidacy revolves around an HI greater than or equal to 3.25.[5,16,17] However, this number is supposed to simply assess the anatomic severity of the pectus defect. With the HI there does not appear to be a substantial correlation between physical limitations, difficulty of repair, longer operative times, and post-operative pain. A series of 271 pectus excavatum repairs with bar placement showed no correlation of the HI with operative time, duration of hospitalization, or bar infection.[18]

More important than whether the HI carries meaningful prognostic value, it may not adequately define the presence or absence of disease. Little data has been generated to validate the accuracy of the HI in separating patients with a pectus deformity from patients with normal chest contour. This is important since the HI has been used as a diagnostic tool for differentiation of disease severe enough to warrant repair from those who may be observed without intervention. The initial description of the HI utilized 19 controls, of which four were under 6 years of age, and 33 patients who underwent correction.[5] After this initial description the HI was clinically incorporated with the aforementioned threshold value of 3.25 without studies to validate the diagnostic accuracy of the HI.

Typically to define an abnormal physiologic parameters for any disease process first a normal must be determined. This is done by establishing a normal distribution and including two standard deviations above or below the mean as a normal. This leaves 2.5% of the assumed normal population who may meet abnormal criteria by chance in either the low or high portions of the distribution.

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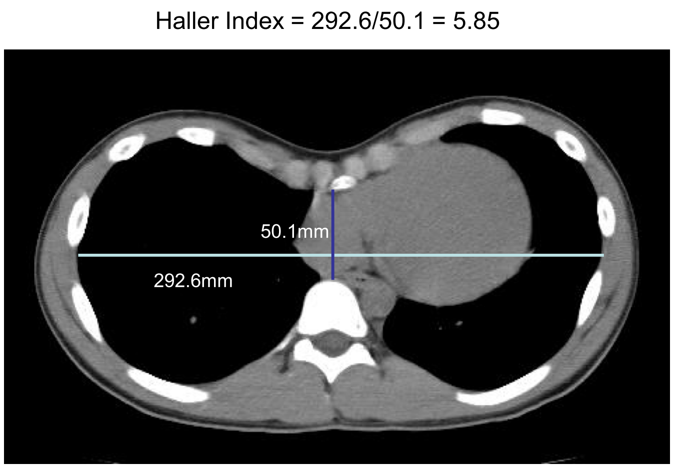

Fig. 1. Demonstration of the calculation for the HI.

An investigation on the accuracy of the HI in separating pectus patients from normal controls used thoracic CT scans to compare patients who had undergone pectus excavatum repair and normal controls.[19] For the control population patients who had undergone a thoracic CT scan for an indication other than pectus excavatum were collected. 10 males and 10 females from each year of age between 8 and 18 were included. This resulted in 20 8-year olds, 20 9-years olds and so on to create a population of 220 patients who represented a comprehensive cohort of controls for all children in the age ranges evaluated for correction. Patients who had been evaluated for pectus excavatum or had this as a diagnosis within their medical record were not considered for the control group.

For the comparison group, 252 patients who had undergone repair of a pectus defect were selected. Pectus patients were chosen for repair upon the agreement of the operating surgeon, patient, and family; that the defect was severe enough to mandate repair and that there would be a substantial improvement from bar placement. Every patient underwent placement with a retrievable bar after chest CT evaluation. The CT scans for both groups were reviewed and both Haller and correction indices were calculated (Fig. 1).

The results were disturbing because several pectus patients had a HI low enough to be within the control group and several control patients had a high enough HI to be within the pectus group (Fig. 2). In total, 47.8% of the total population of both groups fell within the highest control HI and the lowest pectus HI. This represented an unacceptable amount of overlap for a measurement that was being used to separate these two groups.

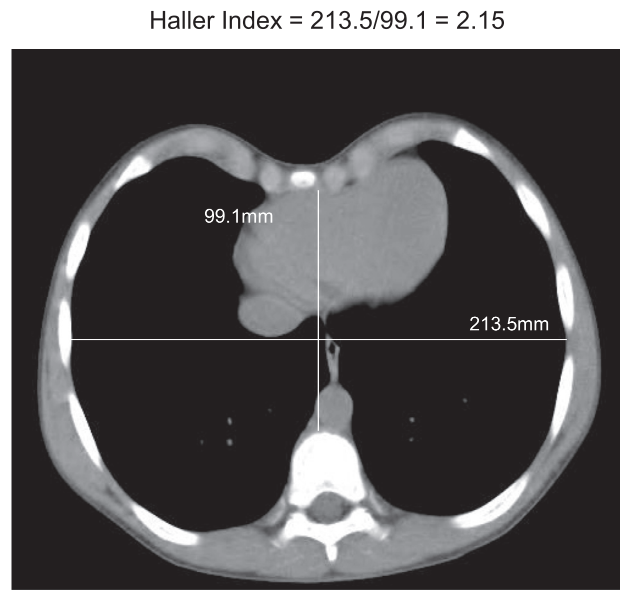

Fig. 3. CT image of the pectus patient with the lowest HI.

The overlap between disease and control groups was large, but in addition, the previously defined HI of 3.25 as a surgical threshold also failed to discriminate patients as it was found 19% of the pectus patients who had undergone repair possessed an HI under this value. These are patients who clearly have a defect as well as the typical clinical manifestations of the disease but the HI did not represent the severity of the defect. An example of such a patient is demonstrated in Fig. 3. On the flip side, a control patient was found to have a HI of 3.75 (Fig. 4) where there is clearly no central thoracic depression. In fact, the sternum is the most anterior point on this patient's chest. These cases demonstrate the limitation of the HI. The measure depends heavily on the width of the chest as the numerator of a simple fraction. Therefore, the patient with a deep chest that is narrow side-to-side can have an impressively severe pectus excavatum defect, which when assessed by the HI,

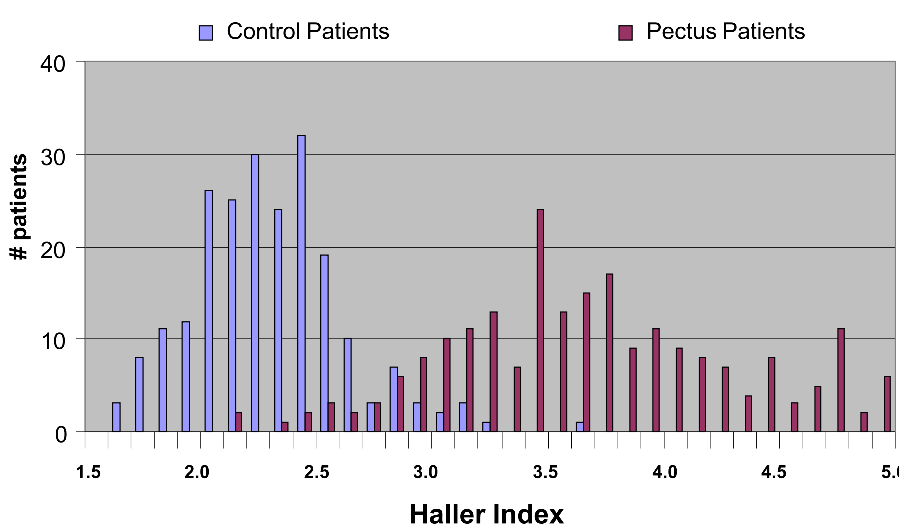

Fig. 2. Histogram for the distribution of HI plotting pectus patients with normal controls. In order to demonstrate both curves for pectus and control patients for HI, those with an HI over 5.5 are not displayed as this end of the curve is long tail of sporadic outliers.

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