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Computed Tomography Lung Volume Changes After Surgical Treatment for Early-Onset Scoliosis

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Abstract

Study Design: Single-center review of prospectively collected data.
Objectives: To document anatomic lung volume and thoracic parameter changes in early-onset scoliosis patients undergoing rib-based (RB), or spine-based (SB) distraction surgical treatment who were too young to perform pulmonary function tests.
Methods: Twenty patients undergoing growth-sparing treatment had computed tomography lung volumes (CTvol) determined by controlled-ventilation CT scanning preoperatively and at a mean of 2.7 years later under an institutional review board (IRB)-approved protocol. Twelve patients had non-congenital curves and 8 had congenital curves. Eleven patients had SB constructs and 9 had RB ones. Computed tomography lung volumes were correlated to T1–12 length, T6 coronal width, pelvic width, and curve magnitude, and were normalized by comparison with age standards and pelvic width.
Results: All patients had increased CTvol at follow-up (RB 51%, SB 46%; $p < .001$). All increased T1–12 length from 128 mm (range, 39–160 mm) preoperatively to 154 mm (range, 61–216 mm) at follow-up. Both RB and SB gained 2.6 cm; this measurement was significant in RB ($p < .001$) owing to the shorter preoperative length. The T1–12 length correlated well with CTvol preoperatively ($p = .002$) and at follow-up ($p = .007$). The T6 width correlated best with CTvol ($r = 0.76$; $p < .001$ preoperatively and at follow-up). Main thoracic curves improved 21° in SB (preoperatively, 78°) versus 1.5° correction in RB (preoperatively, 60.2°). There was no correlation between curve magnitude and CTvol preoperatively or at follow-up. Follow-up CTvol percentile decreased in 10 patients, increased in 6, and was unchanged in 4. The T1–12 length was less than the fifth percentile in all patients preoperatively and increased in 9 patients at follow-up, whereas 11 remained at less than the fifth percentile.
Conclusions: The CTvol quantitates anatomic results of early-onset scoliosis growth-sparing surgery in patients too young for standard pulmonary function tests. Thoracic length and width correlate well with absolute CTvol and are possible surrogate measures. Curve magnitude and correction correlate poorly and assume less importance in outcome evaluation. Thoracic volume and length gains exceeded normal growth in about half of the patients.

Keywords: CT lung volume; Early-onset scoliosis

Introduction

Treatment of early-onset scoliosis (EOS) arguably should focus on maximizing thoracic volume gain as well as deformity correction to minimize the risk of developing thoracic insufficiency syndrome. Current treatments include distraction-based therapies in which spinal fusion is specifically avoided to permit maximal spinal growth, and which have the potential to increase thoracic volume both directly (rib-based [RB] constructs) and indirectly (spine-based [SB] constructs). Unfortunately, there are no current standardized methods to measure thoracic volume. In patients old enough to perform standard pulmonary function tests (PFTs), this method provides a meaningful physiologic measure of lung volume and respiratory function but it is subject to well-known variability related to patient effort, cooperation, technical factors, and physical or neurologic impairments. In patients unable to perform

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standard PFTs, computed tomography (CT) thoracic volume determination (CTvol) under controlled breathing parameters [1] is an important objective anatomic measure of treatment effect on the thorax.

Recognizing the need for an objective method of documenting thoracic volume changes in patients undergoing growth-sparing treatment, we initiated an IRB-approved protocol of obtaining pretreatment and 1 posttreatment CTvol determination in patients with EOS who were unable to perform standard PFT. The purpose of this study was to report changes in CTvol in a cohort of EOS patients undergoing RB or SB non-fusion treatment to attempt to document the anatomic effects of such treatment on thoracic volume.

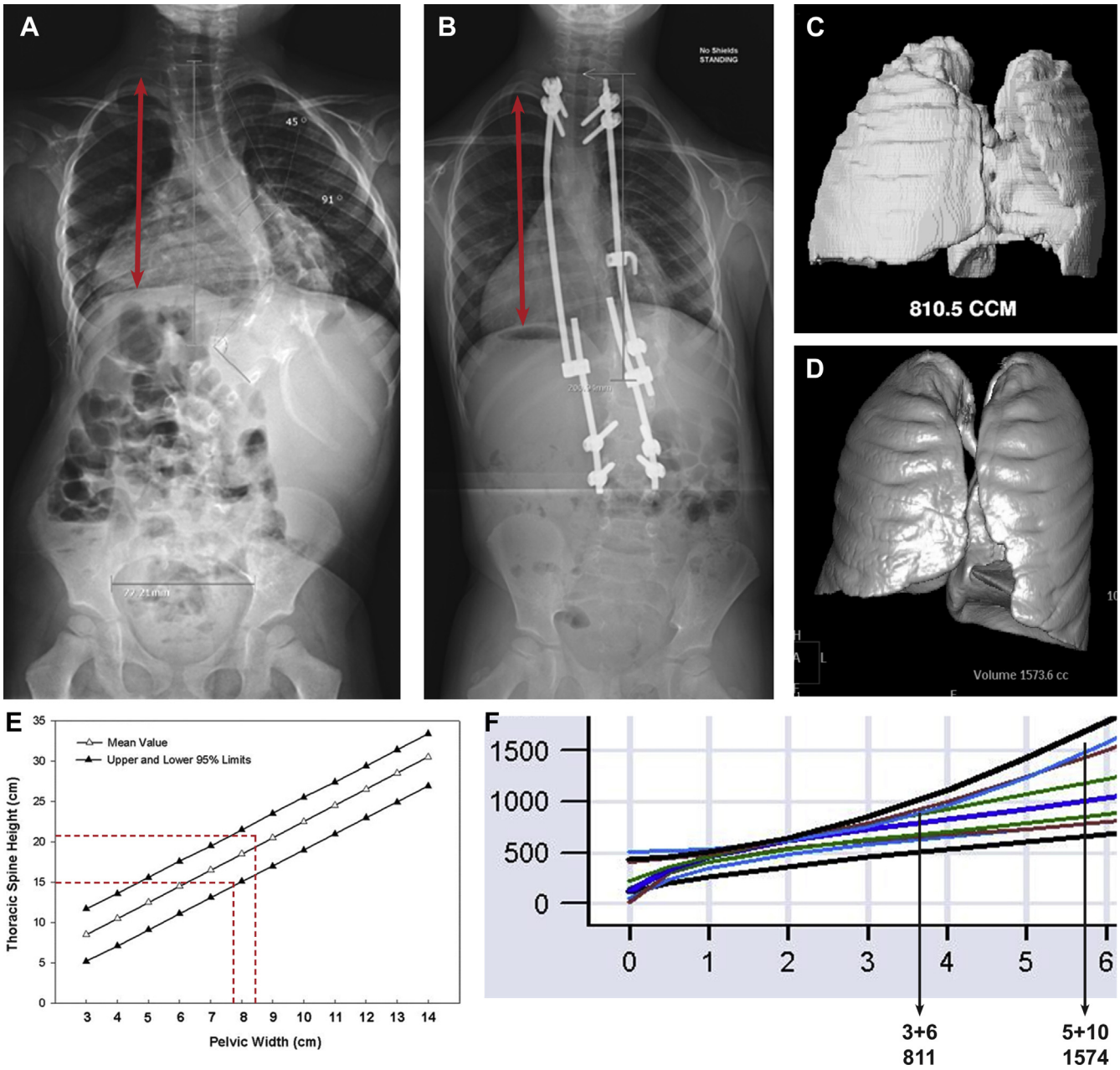

Fig. (A) Preoperative radiograph of a 3-year 6-month-old male with neurofibromatosis-1 and a 91° thoracic scoliosis. T1–12 length = 15 cm. (B) Follow-up radiograph at age 6 years. Curve correction to 49° and T1–12 length = 20.9 cm. The space for the concave lung is clearly enlarged. (C) Preoperative CT lung volume = 811 mL, corresponding to (A). (D) Follow-up lung volume, corresponding to (B) = 1,574 mL. (E) T1–12 length, normalized for pelvic width [2]. Preoperative length (15 cm) has increased from the fifth to approximately the 60th percentile (20.9 cm), which suggests that length gain has exceeded what would be predicted from normal growth. (F) Computed tomography volumes normalized for age [4]. Because of the narrow differences between percentiles in very young children, accurate documentation of percentile change with volume increase is uncertain.