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Vertical expandable prosthetic titanium rib device insertion: does it improve pulmonary function?

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Abstract

Purpose: Vertical expandable prosthetic titanium rib (VEPTR) insertion and expansion has been advocated to increase thoracic volume and pulmonary function in patients with thoracic insufficiency syndrome. We reviewed our experience with VEPTR implantation to determine if lung function and growth is augmented, to determine the children's functional status, and if the scoliosis is controlled.

Methods: From 2006 to 2010, 29 insertions and 57 expansions were performed in 26 patients at our institution. Demographic data were reviewed in conjunction with complications, scoliosis angles, pulmonary function tests (PFTs), and computed tomography–guided 3D reconstructions to determine lung volumes; and quality of life scores were determined using a modified Scoliosis Research Society (SRS) questionnaire preoperatively and postoperatively. The groups were also stratified by age (because of lung growth potential), disease (congenital or infantile scoliosis, Jeune syndrome, neuromuscular, other structural thoracic disorders), and sex. Analyses using SPSS (SPSS, Chicago, Ill) were performed with $P < .05$ considered significant.

Results: Each patient underwent 3.03 ± 1.8 surgeries, spending 0.97 ± 1.8 days in the intensive care unit and 4.41 ± 6 days in the hospital for each procedure. Mean age was 90.7 ± 41 months. Of the 36 complications, most were because of infection (12), half requiring operative repair (hardware removal). The average PFT percent predicted values for forced expiratory volume in 1 second, forced vital capacity, and RV were 54.6 ± 22, 58.1 ± 24, and 145.3 ± 112, respectively, preoperatively and 51.8 ± 20, 55.9 ± 20, and 105.6 ± 31, respectively, postoperatively. The lung volumes measured by computed tomography when corrected for age do not increase significantly postoperatively. The mean Cobb measurement for the preoperative major curves was 64.7° and postoperatively was 46.1° for those curves measured preoperatively, for a 29% curve improvement. All postoperative curves had a mean of 56.4° and 58.1° at final follow-up, a 3% curve increase. The SRS scores for patients remained unchanged and no statistical difference was seen from preoperative to postoperative values. No statistically significant difference was seen in complications, PFT (forced expiratory volume in 1 second, forced vital capacity, RV), lung volumes, scoliosis angles, and SRS scores between sex, age, and disease categories.

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Conclusion: There was mild improvement in scoliosis angles but no improvement in lung function and volume. Scoliosis Research Society scores indicate that the children have near normal function both before and after VEPTR placement. Pulmonary function, lung volume, and patient subjective assessments did not increase dramatically after VEPTR placement, although scoliosis angles improved.

In patients with congenital scoliosis, an alternative to early spinal fusion to prevent a worsening curve is expansion thoracoplasty using vertical expandable prosthetic titanium rib (VEPTR; Synthes Spine Co, West Chester, Pa) insertion and serial lengthening, first described in 1989 [1]. Other indications for VEPTR insertion have later been introduced including thoracic insufficiency syndrome [2,3], where abnormal thoracic structure affects lung development, limiting a patient's functional capacity. Although designed to increase the thoracic volume and lung growth, VEPTR insertion has failed to show improvement using pulmonary function tests (PFTs) in short-term follow-up [2,4-6].

As useful adjuncts to PFTs, 3-dimensional reconstructions of thoracic CT scans (3DCTR) can be used to evaluate lung volumes after thoracic spinal reconstruction procedures [7]. Using a combination of 3DCTR and PFT values, preoperative and postoperative changes can be carefully monitored to determine the effect of VEPTR insertion on pulmonary function. Improvements in ventilation after VEPTR insertion, especially in younger patients, have been described using VQ scans [8], although studies using 3DCTR are limited.

Quality of life variables however do not always reflect the changes seen on these objective measures; therefore, a functional survey was created and refined by the Scoliosis Research Society (SRS) [9,10]. The SRS questionnaire measures a patient's subjective self-assessment in the following areas: function, pain, self-image, mental health, and satisfaction. In this report, we present outcomes after VEPTR insertion and lengthening in our experience, from a prospectively collected database, including complications, changes in scoliosis angles, PFT, volumes from 3DCTR, and results of a modified SRS questionnaire.

2. Methods

A prospectively collected database was established to follow patients with placement of VEPTR device after institutional review board approval. Vertical expandable prosthetic titanium rib insertion was performed by a pediatric surgeon and orthopedic surgeon acting in conjunction using a thoracotomy for placement of the device. Subsequent lengthening procedures were performed serially at an average of 6 months from the previous procedure.

A total of 26 patients (16 male and 10 female) underwent 86 procedures between October 2006 and March 2010 at the University of Michigan in Ann Arbor, Mich. The patients, with an average age of 91 months, underwent 29 insertions (21 bilateral) and 57 expansions. The patients were also evenly grouped above and below 84 months or 7 years of age. The patients were categorized into 4 diagnoses (congenital or infantile scoliosis, Jeune syndrome, neuromuscular scoliosis, and unspecified structural thoracic disorder). Almost half of these patients had congenital or infantile scoliosis (12), whereas the other half was mostly split between neuromuscular scoliosis (5) and unspecified structural thoracic disorder (7). Only 2 patients with Jeune syndrome comprised our VEPTR experience.

Outcome measures included PFT preoperatively and every 6 months in all patients (12) who were not ventilator-dependent and can cooperate with the procedure, lung volumes in patients who consented to 3DCTR preoperatively and yearly (10), a modified SRS-22 questionnaire, and scoliosis angles measured preoperatively and at each postoperative visit in all patients, with 23 of 26 patients having adequate follow-up for analysis of these values. To measure scoliosis angles, standing PA and lateral spine radiographs were obtained. The Cobb measurement was obtained from the largest curve preoperatively, postoperatively, and at final follow-up. The mean Cobb angle measurement was calculated and compared at the different periods. In addition, the lengths of stay, complication rates including return to operating room, PFT results, and lung volumes by 3DCTR were compared among sex, age, and diagnoses groups.

SPSS software (SPSS, Chicago, Ill) was used to analyze all data; and Student t test, analysis of variance, and χ^2 analyses were performed with $P < .05$ considered significant.

3. Results

The 29 VEPTR insertions averaged 6.72 days in the hospital postoperatively, including 2.72 days in the ICU, whereas the 57 lengthening procedures averaged 2.44 days in the hospital, including 0.26 days in the ICU. In all, 36 complications occurred with 22 of 36 treated nonoperatively: 3 transfusions for bleeding, 6 infections treated with antibiotics, 9 neurologic (pain or numbness), 2 hardware dislodgements, and 2 pleural effusions. Reoperation was required in 4 for chest tube placement (pneumothorax), 1 for seroma drainage, 6 for hardware removal (for infection), and 3 for hardware repositioning (for dislodgement).

No statistical difference was noted between preoperative and postoperative values of the pulmonary outcomes for PFT