



Surgeon Experience Does Not Change Rate of Perioperative Surgical Complication in Rib-Based Distraction Surgery for Early-Onset Scoliosis

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Abstract

Objective: To report on the surgical learning curve in treating early-onset scoliosis with rib-based distraction.

Summary of Background Data: The idea of a surgical learning curve proposes improved outcomes with experience. Early-onset scoliosis (EOS) is a challenging condition to treat and complication rates are high.

Methods: All patients from a single experienced spine surgeon's practice who had undergone placement of rib-based distraction constructs between 2002 and 2013 were identified. A retrospective chart review was performed to determine patient characteristics at implantation and follow-up surgeries and complications. The primary outcome was complication rate per surgical encounter. Experience was analyzed both by number of surgical procedures and year in study period.

Results: The surgeon began using rib-based distraction in 2002, and between 2002 and 2013, a total of 101 patients underwent 1,009 implantation or expansion surgeries involving rib-based distraction at a median age of 6 years at implantation (10 months–9.4 years). The median preoperative Cobb angle was 67° (8°–125°; IQR: 57°–76°) and follow-up was a median of 4.4 years (IQR 3.7–5.6 years). Overall, 65.3% of patients experienced complications, including 40 Grade I, 20 Grade II, 126 Grade IIA, and 3 Grade III. Univariate analysis identified a trend toward cumulative number of surgeries relating to a decreased complication rate, with every 50 surgeries decreasing the complication rate by 3% ($p = .071$). However, multivariate analysis found cumulative number of surgeries and complication rate to not be significantly related ($p = .12$). Surgeon experience as measured by study time (as both a continuous and categorical predictor) did not achieve statistical significance in either the univariate or multivariate models.

Conclusion: This is the largest single-surgeon series of EOS patients treated with rib-based distraction. Surgeon experience defined either as number of procedures or years of experience within the study period did not impact the rate of complications.

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Key words: Early-onset scoliosis; Complication; Rib-based distraction

Introduction

Early-onset scoliosis (EOS) is defined as scoliosis with onset less than 10 years of age, regardless of etiology [1]. Within this broader definition, the first five years of life are a period of rapid thoracic growth, during which the development of severe spinal deformity can significantly

inhibit pulmonary development and function at maturity [2,3]. The inability of the thorax to support normal lung growth and respiration has been defined as “thoracic insufficiency syndrome” (TIS) and is often thought of as a concerning and problematic consequence of early onset scoliosis [4]. Growth-friendly techniques that control spinal deformity while allowing for growth of the spine and thorax have become increasingly popular treatments for EOS [5-13]. Rib-based distraction techniques and devices including the Vertical Expandable Prosthetic Titanium Rib (VEPTR) were developed to specifically address TIS in the growing child [4,7]. The goal of the VEPTR was to allow for expansion of the constricted chest wall while simultaneously providing some control of the associated spinal deformity.

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Practice makes perfect—or at the very least, one should get better. This statement is an accepted principle in many tasks, including surgery. The orthopedic literature contains many examples of improved results with increased surgeon experience, documenting the importance of the “learning curve” [14–25]. Surgery for spinal deformity is complex, and surgeon experience has been shown to positively affect surgical efficiency and patient outcomes [26]. One multicenter study of nine surgeons showed increased surgeon experience to be correlated with decreased blood loss, decreased operative time, less pain, and improved health-related quality of life scores, as measured by the Scoliosis Research Society–22 (SRS-22) [26]. But does the “learning curve” apply to treatment of EOS using rib-based distraction? In addition to more complex and challenging deformity, early-onset scoliosis is frequently associated with more comorbidities than adolescent idiopathic scoliosis [7,27,28]. In addition, the successive lengthening procedures required in growth-friendly approaches increase the number of surgical exposures and thus increases the likelihood of complication over the course of treatment. Reported complication rates in patients treated with growth-friendly constructs range between 0.57 and 2.63 episodes per patient [5,10,12,27–29]. These factors combine to make management of EOS using rib-based distraction techniques a uniquely complicated and challenging treatment that one would expect would be positively affected by surgeon experience. This study sought to determine the rate of complications using rib-based distraction procedures and to assess whether complications decrease with surgeon experience.

Materials and Methods

Institutional review board approval was obtained for this retrospective cohort study. Subjects were identified from the Children’s Spine Study Group registry. All patients included in the analysis had undergone placement of rib-based distraction constructs between 2002 and 2013 and were from a single surgeon’s practice. At the beginning of the study period, the surgeon had more than 15 years of postfellowship experience and a high-volume pediatric spinal deformity practice. Inclusion criteria required a diagnosis of early-onset scoliosis, treatment with rib-based distraction, and a minimum of eight months’ follow-up from initial device implantation to allow enough time for at least one planned distraction procedure.

Descriptive statistics were used to summarize patient characteristics at initial implantation. Continuous variables were summarized as median and interquartile range (IQR) for skewed variables and mean and standard deviation (SD) otherwise. Disease severity at initial implant was classified as mild, moderate, or severe by the principal surgeon. Likewise, EOS classification was based on degree of spinal deformity, etiology of scoliosis, and comorbidities at the time of initial implant using the EOS classification system developed by Williams et al. [1].

The primary outcome was complication rate per surgical encounter using the surgical complications classification system described by Smith et al., specific to growing spine surgery in EOS [30]. Median time to first complication was estimated using the Kaplan–Meier (KM) method. KM plots depicting time to first complication were created stratified by surgeon experience variables (study time and cumulative surgeries), patient age at initial implant and disease severity; where continuous variables were divided into tertiles. Log-rank tests were used to compare time to first complication across categories. We report complication incidence rate per 1,000 person-days and complication incidence per 50 surgeries with 95% confidence intervals (CIs) estimated with bootstrapping using the adjusted bootstrap percentile method with 10,000 replicates.

A Poisson generalized estimating equation (GEE) regression model was used to assess the effect of surgeon experience on the number of complications per surgical encounter. Surgeon experience was quantified by the following metrics: number of cumulative surgeries performed prior to the current surgical encounter (in units of 50 surgeries); surgery year, treated as a continuous variable between 2002 and 2013; and surgery year treated as a categorical variable (2002–2005, 2006–2008, 2009–2013), where categories were defined to create tertiles with similar surgical volumes. An exchangeable correlation structure was used to adjust for repeated measures within each subject, and robust standard errors were used to calculate 95% CI and p-values of model coefficients. Coefficients were exponentiated to estimate incident rate ratios (IRRs). Statistical analyses were conducted in SAS v.9.4 software. All tests were two-tailed and evaluated at a .05 level for statistical significance, and a range of .05–.1 was interpreted as weak evidence for an effect.

Results

One hundred one patients met inclusion criteria. Age at initial implantation ranged from 10 months to 9.4 years, with a median age of 6 years (Table 1). Fifty-two patients were male and 49 were female. Based on major curve Cobb angle magnitude, 22 patients were classified as mild, 43 as moderate, and 36 as severe. The median preoperative Cobb angle was 67° (8°–125°; IQR: 57°–76°).

During the study period, 1,009 VEPTR surgeries were performed and there were 183 total complications (Table 2). This included 101 initial implantations, 95 exchanges, 78 revision procedures, 15 additional implantations (supplementary fixation), 15 removals, and 705 expansion procedures. Median follow-up was 4.4 years (IQR 3.7–5.6). Thirty-five patients had no complications (34.7%), 66 had one or more, and 40 had two or more. The incidence rate per 50 surgeries was 9.07 (95% CI: 7.35–11.6). The percentage of complications by study year, standardized by person time, is shown in Figure 1. The first year (2003) had a complication rate of 51.4%,

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