Vertical Expandable Prosthetic Titanium Rib (VEPTR Technique)

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Abstract

Objective: To evaluate the technique and assess radiological outcomes in early onset scoliosis patients treated with VEPTR technique.

Design: Retrospective study.

Patients: 30 patients with early onset scoliosis with minimum follow-up 1 year and maximum follow-up 6 years.

Intervention: 25 patients were treated by VEPTR and 5 patients were treated by other rib-based distraction systems using VEPTR technique.

Main Outcome Measurement: Radiographs were evaluated to compare pre-operative and post-operative (last follow-up) changes in sagittal and coronal changes in Cobb’s angels as well as the change in Space Available for Lung (SAL) ratio.

Results: 8 cases of congenital scoliosis, 3 infantile scoliosis and the others were scoliosis associated with; spinal cord tumors, osteogenesis imperfecta, Jarcho Levin syndrome, spinal muscular atrophy, arthrogryposis, and congenital myopathy. The age at surgery varied between 2 and 10 years (6.7). The average Cobb’s angle preoperatively in the antero-posterior view was 88.2º, while the post-operative average was 57.3º (percentage of correction 34%). The average (SAL%) was 77.9% pre-operatively, and has been improved to become 93.5% post-operatively (improvement 25%).

Complications: The complications rate was (40%). Complications varied from mortality “one case (3.3%)” to skin slough, surgical site infection, junctional kyphosis, metal failure, and pelvic hook migration.

Conclusion: VEPTR technique represents a good alternative to “spine to spine growing rod techniques” in well selected cases. Complications rate is high with regard to the nature of deformity and number of “lengthening procedures”.

Key Words: VEPTR – Scoliosis and spine growth friendly technique.

Introduction

The vertical expandable prosthetic titanium rib (VEPTR, Synthes North America, West Chester, PA) technique was originally designed for management of cases with thoracic insufficiency secondary to congenital anomalies with fused ribs, hypoplastic chest wall deformities, and early-onset scoliosis. The device can be attached from rib to rib to treat chest wall deformity and from the ribs to the spine or ileum to treat scoliosis [1-3]. The VEPTR technique with expansion thoracostomy can provide the option of treating both spine and chest wall deformity while allowing for continued growth. The greatest benefit of VEPTR technique is thought to be in children younger than 8 years of age because alveolar development can continue until this age [4,5].

The surgical concept of VEPTR technique is based on the expansion of the thorax by rib distraction on the concave side of the curve [6].

Patients and Methods

The study was conducted from June 2008 to June 2014 in Nasser Institute we evaluated 30 patients with early onset scoliosis of mixed etiologies. To be included in the series, a patient had to have progressive early onset scoliosis, younger than 10 year old at the time of surgery. Patients with absent diaphragmatic function, inadequate proximal or distal rib attachment, inadequate soft tissue coverage, age beyond skeletal maturity or infection at operative site were excluded from our study. The 30 cases were followed-up for a minimum of 1 year and maximum of 6 years (mean=3.4).
Study population:

8 cases of congenital scoliosis, 3 infantile idiopathic scoliosis and the others associated with spinal cord tumors, osteogenesis imperfecta, Jarcho Levin syndrome, spinal muscular atrophy, arthrogryposis, and congenital myopathy. All patients had full history and clinical examination. Radiologic assessment using X-ray was done routinely. Magnetic Resonance Imaging (MRI) was done routinely. Data was collected for all patients retrospectively. The 30 cases were followed-up for a minimum of 1 year and maximum of 6 years.

Surgical technique:

VEPTR was performed in 25 cases, and VEPTR technique (using other pediatric spine implants) was used in 5 cases.

VEPTR technique was performed under general anesthesia in an operating room using sterile technique. All patients received prophylactic intravenous antibiotics within 1 hour before skin incision. Surgeries were done with the patient in a lateral decubitus position with the concave hemithorax side upward or in prone position with standard 'J'-shaped incision (22 cases), midline spinal incision (3 cases) or paramedian incision (5 cases). Arterial lines and central venous catheters were used. Intraoperative neuro-monitoring or wake-up test and upper extremity pulse oximetry were used (during implantation surgery and during device replacement.

The hooks of the superior portion of the device were placed posteriorly and as medial as possible without spinal exposure and secured around a stable rib (or two ribs in case of small ribs) with the exclusion of the first rib, which was routinely avoided. The 3rd, 4th or 5th rib was chosen according to the upper end vertebra of the scoliosis curve. The proximal rib is selected and confirmed using fluoroscopy imaging.

Rib-to-pelvis construct was preferred in cases with severe thoracolumbar curves and in patients with absent posterior lumbar spinal elements and bad skin condition in the midline. Also in neuro-muscular, or other cases with large and rapidly progressive curves extending to the pelvis.

When the inferior attachment site was the ilium, a vertical incision was made and the iliac crest was exposed to place an S hook in the junction between middle and posterior thirds of iliac crest after connecting the S hook with a domino rod connector. The superior and inferior attachment sites were connected using a submuscular track as in rib-to-spine construct, and the device was passed and connected. When the rib-to-ilium construct was used bilaterally it was called “Eiffel Tower construct”.

Two implants were used in case of open wedge thoracoplasty on the affected side. One lateral construct from proximal rib/s to distal rib/s and 1 medial construct from proximal rib/s to one lumbar vertebra (or two) or iliac crest distally.

In case of using other pediatric spine implants; the same exposure was done as mentioned before and rib hook (Mont Blanc Baby rib hook) was inserted as close as much to the tip of transverse process for one or two ribs (one or two rib hooks) after excluding the 1st rib. In case of using spine hooks for ribs; two hooks were used to make claw to support proximal and distal rib attachments in case of thoracoplasty or proximal rib attachment only for hybrid distractor "Thorax to lumbar spine or pelvis". The connection between the proximal and distal rib claws or hooks was done using “Domino” rod connectors. The technique of passing the rods was done from proximal to distal through submuscular tract as classic VEPTR technique.

Skin and soft tissue were be manually manipulated to create skin and muscle flaps for implant coverage using Campbell's technique by stretching the skin for a few minutes before closure. Distraction procedures were done on average every 6 months.

Radiological evaluation:

Pre-operative and post-operative measurement of Cobb's angel in erect anteroposterior and lateral radiographs to assess the coronal and sagittal correction as well as the (SAL) improvement (is calculated by taking the ratio of the distance from the apex of the most cephalad rib to the highest point of the concave side divided by the convex side) [7].

Complication rate:

The rate of complications in the final follow-up.

Statistical methodology:

Statistics were done using IBM computer with SPSS (Statistical Program for Social Science Version 12). p-values less than 0.05 was considered statistically significant.
Fig. (1): Exposure of the thorax.

Fig. (2): Insertion of superior hooks (rib support) of the device.

Fig. (3): Steps of measurement and insertion of lumbar extension rod.

Fig. (4): Two implants are used to open the wedge (in expansion thoracoplasty).
Results

The patients were followed-up for a mean of 3.4 years (range 1 to 6 years). 86.7% of cases were followed-up for 2 years or more. The mean number of lengthening procedures was 5.3 times and (range 2 to 11). The device was changed 9 times in the studied group (mean=0.3) for having the possibility of more lengthening procedures. The total number of lengthening procedures was 160.

The lower fixation level was lumbar spine (70%). The lower fixation level was iliac crest (30%). L2 or L3 levels were selected in 50% of cases. L4 was selected in 20% of cases. The 5th rib was the upper fixation level in 50% of cases; the 3rd rib was the upper fixation level in 30% and the 4th rib in 20%. 28 cases (93.3%) had expansion thoracoplasty in addition to rib-to-spine/or iliac crest construct.

Pre-operative Cobb’s angle (mean 88.2°) of thoracic deformity was corrected to (mean 57.3°), for a mean curve correction of 34%, which was statistically significant. Change in thoracic kyphosis was statistically insignificant. Space Available for Lung (SAL) ratio improved from 77.9% to become 93.5%. Skin complications rate was.

Complications:

One mortality case occurred due to chest infection after a lengthening procedure. In 7 cases the devices was changed to growing rods, 4 cases the change was after delayed deep infection and skin slough, and 3 case was after severe proximal junctional kyphosis. The skin complications were the highest (16.7%), followed by proximal junctional kyphosis and other complications such as rod breakage, rib breakage and hardware dislodgement. The complications rate was 40%.

Table (1): Radiological results (coronal, sagittal correction and SAL ratio).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean Pre-operative</th>
<th>Post-operative last follow-up</th>
<th>% of change</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scoliosis curve Cobb’s angle</td>
<td>88.2±14</td>
<td>57.3±10</td>
<td>34%</td>
<td>11.7</td>
<td>0.000HS</td>
</tr>
<tr>
<td>Thoracic Kyphosis Cobb's angle</td>
<td>59.3±20</td>
<td>50±23</td>
<td>18%</td>
<td>1.2</td>
<td>0.39NS</td>
</tr>
<tr>
<td>Space Available for Lung (SAL) ratio</td>
<td>77.9±14</td>
<td>93.5±13</td>
<td>25%</td>
<td>3.7</td>
<td>0.03S</td>
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</tbody>
</table>

Discussion

In our patients the mean scoliosis improved from 88.2±14 to 57.3±10 degrees (34% correction) after VEPTR insertion at the latest follow-up. Comparing the percentage of scoliosis correction to other results in the literature we did notice that the results in the published studies are variable (16.3% to 59%) [8-15]. Our findings are similar to those of Hasler et al. [10] who found significant correction of scoliosis by (30%). Smith, [15] using a bilateral rib-to-pelvis VEPTR construct, achieved 32% correction of the main curve. Our results regarding the scoliosis deformity like the results
of other studies in the literature (in spite of the variability of results) concludes that VEPTR technique can prevent progression and correct scoliosis deformity significantly but the percentage of correction is variable. Our results regarding sagittal correction showed insignificant changes in sagittal Cobb’s angle.

The Space Available for Lung (SAL) ratio improved significantly in our series. The average SAL preoperatively was 77.9% and it was increased to an average of 93.5 postoperatively. This was statistically significant \( (p=0.03) \). These results are less than what was achieved by Joshua et al. [16], which ranged from 42% to 50% improvement in SAL with Spondylothoracic dysplasia and spondylocostal dystostosis respectively. In our series the average SAL improvement was 25% which was comparable to Dede et al. [14], Campbell et al. [11] and slightly superior to the results of Ramirez et al. [13]. Our results as well as the conclusion from other studies confirm that the VEPTR technique stabilizes the thoracic cavity in what would otherwise have been a progressive deformity leading to diminished space available for lung.

In 2010, Sankar et al. [17] reported a comparison of complications among growing spinal implants. This study compared standard dual growing rods, hybrid growing rods with rib anchors proximally and spine anchors distally, and VEPTR. There is no statistically significant difference between complications rate in the 3 implants systems with almost similar outcome of growing rods and VEPTR [17]. The rate of patients who develop complications after VEPTR technique in our literature review varies from study to study. Complications occur in about one third of patient in some studies [18,19,20]. Others like Murphy et al. [9] reported complications rate of 60%, however, device related complications are 44% only. Hasler et al., reported 40% of patients had complications. Campbell et al., reported 77% of patients had complications [21]. In our study 40% of cases developed device related complications. We had 1 mortality because of chest infection a few weeks after a lengthening procedure (is not device related).

Rate of patients who developed skin complications in our study is 16.7% with skin slough rate of 13.3%. The rate of skin slough in our literature review varies from 4.5% to 18% [22,23,24]. Skin problems are common complications in our study. Out of 5 patients who developed skin problems, 4 progressed to skin slough and 3 required removal of the device (changed with growing rods). We recommend having enough skin and soft tissue coverage at the initial device implantation and in cases of occurrence of surgical site infection, early aggressive debridement and management of skin complications may help to avoid implants removal.

**Conclusion:**

VEPTR technique indications will continue to evolve. We are still either under using it or over using it. VEPTR technique provides good alternative to spine based distraction techniques in early
onset scoliosis cases. It gives the opportunity for avoiding proximal spine device attachment and in some cases also distal attachment too. This has the advantage of avoiding the effects of law of diminished returns which occurs with spine based distraction systems.

References


تقنية ضلع التيتانيوم الصناعي القابل للتمدد رأسياً

تقنية ضلع التيتانيوم الصناعي القابل للتمدد رأسياً هي واحدة من التقنيات المعتدلة على الشد والصيغة لنمو العمود الفقري. على التقضي من تقنيات القضبان النامية، تقنية ضلع التيتانيوم الصناعي القابل للتمدد رأسياً لديها ميزة التفاعل مع كل من تشويعات العمود الفقري وتشوهات القفص الصدري أيضاً مع مكانيكاً عدماً الحاجة للعرض للعمود الفقري في المرضى الذين يعانون من جذاع ذو البداية المبكرة وغيرها من تشوهات العمود الفقري.

ينبغي اتباع نهج متعدد التخصصات في علاج المرضى عند استخدام هذه التقنية بهدف تحسين وضعهم الغذائي والحالة العامة لهم قبل وبعد الجراحة. كذلك، كما حققت أن هذا الأساليب يرتبط مع إجراءات إطالة متكررة ينبغي محاكاة مع عائلات المرضى.

تقنية ضلع التيتانيوم الصناعي القابل للتمدد رأسياً أو غيرها من تقنيات الشد المعتمد على الضلع يمكن استخدامها لتحقيق أهدافنا لأجل المرضى. عند استخدام تقنية ضلع التيتانيوم الصناعي القابل للتمدد رأسياً، الخياارات هي الثدي من ضلع إلى ضلع أو من ضلع إلى العمود الفقري، أو من ضلع إلى عظم الحرقلة. لتحديد أي من هذه الخياارات، يتطلب من التشويع الذي يتم عليه عند استخدام تقنيات أخرى للشد المعتمد على الضلع، الخياارات هي ضلع إلى ضلع أو ضلع إلى العمود الفقري، يتم تحديد الضلع الأول وفقاً لمستوى قوة الضرائب العظمية. المستوي السفلي للتشوه يمكن أن يكون العمود الفقري القطني في المنحنى الصدرية أو الحرقلة في المنحنى المرتبطة بالشلل أومنحنى أسفل الظهر.

أظهرت دراستنا أن تقنية ضلع التيتانيوم الصناعي القابل للتمدد رأسياً تحسن التشويعات الاتكالية في مرضى الجلاف وتحسن تحسين نسبة المساكن المتاحة للمرضى (SAL) بمعدل 50% (p<0.01). وظهرت النتائج التي توصلنا إليها بشأن تقديم التشوهات السمى انسحاب بسيط في رواية تحد الصدر، لكن هذه النتيجة لم تكن دالة إ見積もり.

وكان معدل المضاعفات المرتبطة مع تقنية ضلع التيتانيوم الصناعي القابل للتمدد رأسياً 40٪ وهي نسبة مرتفعة. لكن، بالوضوح في الاعتبار أن لدينا 40 مريضاً تم لهم 180 إجراء إطالة بالإضافة إلى 70 عملية جراحية إبداعية (مجموع 190 عملية). نجد أن نسبة المضاعفات هذه لها ما يبرزها، كما أنها مماثلة لدراسات أخرى في التفويض العلمي.