Declined Pulmonary Function and Malnutrition before Traditional Growing Rod Placement may Increase Perioperative Complications in Patients with Early-Onset Scoliosis: a retrospective observational study

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INTRODUCTION: It is well established that traditional growing rod (TGR) technique is associated with high complication rate. Most evidences regarding risk factors for perioperative complication focus on radiograph and mechanical features. This study investigated whether pulmonary function or nutritional status affect complication rate after repeated TGR procedures.

METHODS:

A retrospective observation study was conducted between 2006 and 2017. Patients with early-onset scoliosis (EOS) underwent TGR placement and lengthening in our institute were reviewed. The cohort was further divided into 2 categories based on whether the patient had at least one complication from the index surgery to most recent follow-up or to final fusion. Patient characteristics, including their predicted forced expiratory volume in 1 second (FEV_1) and forced vital capacity (FVC), body mass index (BMI) and serum albumin level before TGR placement were analyzed between two groups. Patients without a minimum of 2 years follow-up or completed data collected were excluded.

An independent-samples *t* test was employed to compare continuous variables between groups. A Chi-squared test was used to compare categorical variables. A multivariable stepwise regression analysis was performed for the potential risk factors to cause complications. The "best" model was according to the value of the adjusted R square. The results would be presented in coefficient (CE) and odds ratio (OR). Statistical significance was defined as $p < .05$.

RESULTS:

45 patients met inclusion criteria and enrolled, 20 patients had no complication and 25 patients experienced at least one complication from the index surgery to most recent follow-up or final fusion. The complication group manifested significantly more nonidiopathic EOS etiology (75% vs. 25%, $p < .01$), lower predicted FEV_1 (43% vs. 56%, $p = .04$) and FVC (46% vs. 58%, $p = .03$), lower BMI (18.7 kg/m^2 vs. 22.4 kg/m^2, $p < .01$) and serum albumin (3.7 g/dL vs. 4.3 g/dL, $p = .02$) before index surgery (Table 1).

Predicted FEV_1 and FVC, BMI and serum albumin were further analyzed in patients with different EOS etiologies. Similar to results above, the complication group consistently demonstrated significantly lower predicted FEV_1 and FVC, lower BMI and serum albumin before index surgery among all EOS pathologies (Table 2).

Multiple stepwise regression showed the most reliable factors for the model were nonidiopathic etiology, predicted FEV_1 and FVC, BMI and serum albumin before index surgery which had the largest adjusted R square value ($R = .83$). Independent factors to cause complication included nonidiopathic etiology (CE = −.35, OR = 9.8, $p < .01$), BMI< 20 kg/m^2 (CE = −.09, OR = 15.3, $p < .01$) and serum albumin < 4 g/dL (CE = −.28, OR = 5.5, $P < .01$) before TGR implantation.

DISCUSSION AND CONCLUSION:

Risk factors for perioperative complications after TGR surgeries varied in previous studies, possibly due to different outcome measurements and heterogeneity in EOS etiology and medical complexity. To our knowledge, most studies analyzed risk factors with respect to radiographic parameters of scoliosis or biomechanical features of rod constructs. Our study provided a medium-term follow-up result regarding the effect of declined pulmonary function and malnutrition on perioperative complication. In our cohort, complication group not only had a significantly higher proportion of nonidiopathic etiology, but also consistently demonstrated lower predicted FEV_1 and FVC, lower BMI and serum albumin before TGR placement regardless of their EOS pathologies. Despite this is a small sample study, our findings may have the potential to justify the need for further large scale research.

In conclusion, patients with nonidiopathic EOS, lower predicted FEV_1 and FVC, lower BMI and serum albumin before TGR placement may have greater odds of complications after repeated TGR procedures.

Table 1 Patient characteristics (continued)

	Complications (+)	Complication (-)	P
SAL ratio			
Preoperation	.78 (.60-.94)	.80 (.64-.92)	.38
At last follow-up	.83 (.61-.99)	.82 (.65-.96)	.43
T1 to T12 height (mm)			
Preoperation	144.6 (103.2-190.4)	146.0 (120.5-201.8)	.46
At last follow-up	184.3 (152.7-220.6)	187.0 (155.8-248.5)	.41
Mean EOSQ-24 score			
Preoperation	78.2 (70-81)	77.1 (58-90)	.37
At last follow-up	75.5 (60-89)	79.8 (58-90)	.15
Mean preoperative BMI (kg/m2)	18.7 (16-24)	22.4 (18-25)	< .01
Mean preoperative serum albumin (g/dL)	3.7 (2.8-4.8)	4.3 (3.5-5.1)	.02
ASA class I/II	23 (92%)	18 (90%)	.99
ASA class III/IV	2 (8%)	2 (10%)	.99
Mean operation time (hours)			
Index surgery	4.2 (3.3-6.2)	4.5 (3.7-5.8)	.19
Lengthening procedures	1.1 (0.8-1.4)	1.3 (0.6-1.2)	.38
Mean blood loss (ml)			
Index surgery	494.0 (200-1100)	525.0 (300-1300)	.41
Lengthening procedures	238.0 (100-500)	262.5 (150-650)	.36
Mean length of stay (days)			
Index surgery	4.6 (2-7)	5.3 (3-12)	.30
Lengthening procedures	2.7 (1-5)	3.5 (1-7)	.33

FEV_1: forced expiratory volume in one second; FVC: expiratory forced vital capacity; SAL: space available for lung; EOSQ-24: 24-Item early onset scoliosis questionnaires; BMI: body mass index; ASA: American Society of Anesthesiologists

[a]Five congenital scoliosis, 5 congenital scoliosis combined syndromic scoliosis, 4 congenital scoliosis combined neuromuscular scoliosis, 3 neuromuscular scoliosis and 4 syndromic scoliosis

[b]Three congenital scoliosis, 1 congenital scoliosis combined syndromic scoliosis, 3 syndromic scoliosis

Table 1 Patient characteristics

	Complications (+)	Complication (-)	P
Numbers	25 (56%)	20 (44%)	-
Mean age at index surgery (years)	8.7 (5.2-13.8)	8.1 (6.2-12.5)	.34
Mean follow-up duration (years)	6.2 (2.3-9.8)	6.8 (2.9-10.4)	.35
Sex, Female	15 (60%)	10 (50%)	.99
Mean lengthening procedures (times)	8.5 (7.17)	7.8 (2.11)	.32
Mean interval between lengthening (months)	6.2 (5-7.2)	5.7 (4-9.7)	.26
Mean vertebra spanned	13.7 (11-16)	14 (11-16)	.36
Etiology			
Idiopathic scoliosis	4 (24%)	13 (76%)	< .01
Nonidiopathic scoliosis	21[a](75%)	7[b] (25%)	< .01
Growing rod construct			
Dual	18 (55%)	15 (45%)	.99
Single	7 (58%)	5 (42%)	.99
Mean major curve angle (degree)			
Preoperation	67 (52-80)	63 (53-74)	.24
After index surgery	42 (26-65)	44 (27-66)	.41
At last follow-up	43 (28-54)	45 (23-74)	.40
Mean thoracic kyphosis angle (degree)			
Preoperation	43 (28-62)	45 (27-64)	.37
After index surgery	52 (28-64)	49 (30-59)	.28
At last follow-up	53 (25-64)	55 (41-82)	.35
Mean increase of T1 to S1 length (mm)			
After index surgery	33.9 (26.8-50.3)	37.7 (28.2-64.1)	.23
At last follow-up	101.1 (55.4-190.2)	103.8 (46.4-165.5)	.44
Mean predicted FEV_1 (%)			
Preoperation	43 (20-72)	56 (42-86)	.04
At last follow-up	49 (15-75)	58 (40-80)	.13
Mean predicted FVC (%)			
Preoperation	46 (24-72)	58 (42-81)	.03
At last follow-up	49 (25-73)	61 (44-89)	.06

(continued)

Table 2 Pulmonary function and nutritional status based on etiology (continued)

	Complication (+)	Complication (-)	P
Congenital scoliosis combined neuromuscular scoliosis			
Numbers	4	0	-
Mean preoperative predicted FEV_1 (%)	26 (20-31)	56 (42-86)[a]	< .01
Mean preoperative predicted FVC (%)	33 (24-40)	58 (42-81)[a]	< .01
Mean preoperative BMI (kg/m2)	18.7 (16-20)	22.4 (18-25)[a]	< .01
Mean preoperative albumin (g/dL)	3.1 (2.8-3.6)	4.3 (3.5-5.1)[a]	< .01

FEV_1: forced expiratory volume in one second; FVC: expiratory forced vital capacity; BMI: body mass index

[a]Data from all patients without complication were used as reference if no control group in specific etiology

Table 2 Pulmonary function and nutritional status based on scoliosis etiology

	Complication (+)	Complication (-)	P
Idiopathic scoliosis			
Numbers	4	13	-
Mean preoperative predicted FEV_1 (%)	47 (42-52)	64 (53-86)	< .01
Mean preoperative predicted FVC (%)	48 (42-55)	69 (58-81)	< .01
Mean preoperative BMI (kg/m2)	18 (17-20)	22.6 (19-25)	< .01
Mean preoperative albumin (g/dL)	3.9 (3.6-4.1)	4.6 (4-5.1)	< .01
Congenital scoliosis			
Numbers	5	3	-
Mean preoperative predicted FEV_1 (%)	44 (40-51)	55 (49-59)	.02
Mean preoperative predicted FVC (%)	49 (46-53)	56 (51-58)	.04
Mean preoperative BMI (kg/m2)	19.2 (18-21)	22.7 (21-24)	.01
Mean preoperative albumin (g/dL)	3.4 (3-3.9)	4.2 (3.9-4.4)	.03
Neuromuscular scoliosis			
Numbers	3	0	-
Mean preoperative predicted FEV_1 (%)	33 (28-40)	56 (42-86)[a]	< .01
Mean preoperative predicted FVC (%)	41(39-44)	58 (42-81)[a]	< .01
Mean preoperative BMI (kg/m2)	18.3 (17-20)	22.4 (18-25)[a]	< .01
Mean preoperative albumin (g/dL)	3.5 (3-3.9)	4.3 (3.5-5.1)[a]	< .01
Syndromic scoliosis			
Numbers	4	3	-
Mean preoperative predicted FEV_1 (%)	42 (36-46)	56 (55-57)	< .01
Mean preoperative predicted FVC (%)	45 (44-49)	55 (54-56)	< .01
Mean preoperative BMI (kg/m2)	17.5 (16-19)	22.3 (19-25)	.03
Mean preoperative albumin (g/dL)	3.5 (3.2-3.8)	4.3 (4.2-4.4)	< .01
Congenital scoliosis combined syndromic scoliosis			
Numbers	5	1	-
Mean preoperative predicted FEV_1 (%)	37 (29-45)	55	< .01
Mean preoperative predicted FVC (%)	42 (40-44)	57	< .01
Mean preoperative BMI (kg/m2)	18.6 (17-22)	23	.03
Mean preoperative albumin (g/dL)	3.4 (2.8-3.6)	4.2	.02

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