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Evaluation of factors determining pulmonary function in paediatric scoliosis

Amit Dwivedi[1], Ashok Kumar[2*]
[1] Assistant Professor, Department of Orthopedics, Santosh Medical College & Hospital, Ghaziabad, Uttar Pradesh, India
[2] Professor, Department of Orthopedics, Santosh Medical College & Hospital, Ghaziabad, Uttar Pradesh, India
*Corresponding Author : Ashok Kumar

Abstract
Scoliosis affects approximately 7 million people in the United States. Infantile scoliosis is a rare entity, amounting for less than 1% of population.
Aims and Objectives: To evaluate the factors determining the pulmonary function tests in cases of idiopathic paediatric scoliosis.
Materials and Methods: The proposed study was conducted in the department of Orthopedics Surgery, King George's Medical University Lucknow. The open ended study had been conducted on children having scoliosis in Paediateric age group and attending our outpatient department during August 2011 to July 2012. Detailed history and clinic-radiological examination was done. Total 33 patients were included in the study as per inclusion-exclusion criteria.
Results and Discussion: Clinic-radiological factors have an effect on pulmonary function test in scoliosis patients of paediatric age group. There is significant reduction in FVC and other parameters of PFT in Idiopathic scoliosis patients of paediatric age group.
Conclusion: Cardiopulmonary status of the patient is an important and vital parameter in the follow up of natural history of scoliosis, as it may affect the overall performance of the individual affected by this condition. Preoperative pulmonary function tests are essential to assess surgical risk in a patient with scoliosis because of the possibility of further compromising the pulmonary function.

Keywords: idiopathic scoliosis, pulmonary function test, paediatric age, cobb's angle, cardiopulmonary status

Introduction

Scoliosis (from Greek: *skoliōsis* meaning from *skolios, "crooked")* is a medical condition in which a person's spine is curved from side to side. Although it is complex three-dimensional deformity, on an X-ray, viewed from the rear, the spine of an individual with scoliosis may look more like an "S" or a "C" than a straight line. Scoliosis is defined as a curve of more than 10 degrees [1-3].

Scoliosis is typically classified as either congenital (caused by vertebral anomalies present at birth), idiopathic (cause unknown, sub-classified as infantile, juvenile, adolescent, or adult, according to when onset occurred), or neuromuscular (having developed as a secondary symptom of another condition, such as spina bifida, cerebral palsy, spinal muscular atrophy, or physical trauma). There are two types of scoliosis. Non-structural (mobile) scoliosis is usually caused by a condition outside the spine and disappears when that is corrected. For example, if one of your legs is longer than the other, the curvature in your spine will disappear when you sit down [4].

This condition affects approximately 7 million people in the United States. Infantile scoliosis is a rare entity, amounting for less than 1% of population. This condition is more common in Europe than in US [5].

The infantile idiopathic scoliosis occurs before the age of 3 years and is seen more frequently in boys than girls. Most cases resolve spontaneously, but some may progress to more severe deformity. Juvenile idiopathic scoliosis is defined as scoliosis occurring between the age of 3 to 9 years. It is more frequent in girls. Adolescent idiopathic scoliosis occurs between ages of 10 years to young adult (18 years). This condition is by far the most common type of scoliosis, as well as the type with best prognosis. In general, the severity of the scoliosis depends on the degree of the curvature and whether it threatens vital organs, specifically the lungs and heart [4, 5].

Mild Scoliosis (less than 20 degrees), Moderate Scoliosis (between 25 and 70 degrees), Severe Scoliosis (over 70 degrees) and very severe scoliosis (Over 100 degrees).

Many adolescent girls who have scoliosis also have osteopenia. Some experts recommend measuring bone mineral density when a patient is diagnosed with scoliosis. The prognosis for a person with scoliosis depends on many factors, including the age at which scoliosis begins and the treatment received. Analysis of the efficacy of treatment in idiopathic scoliosis patients depends on understanding the natural history of the untreated condition and comparing it with the outcomes of treatment. Cardiopulmonary status of the patient is an important and vital parameter in the follow up of natural history of scoliosis, as it may affect the overall performance of the individual affected by this condition. It has been stated that preoperative pulmonary function tests are essential to assess surgical risk in a patient with scoliosis because of the possibility of further compromising the pulmonary function [6].

Pulmonary function becomes limited as thoracic scoliosis becomes more severe (80 to 90 degree or more). Forced vital capacity (FVC) and forced expiratory volume in one second

(FEV1) decrease linearly, with approximately a 20% reduction in predicted values in those with curves of 100 degree. The associated deformity of the chest cavity causes restrictive lung disease. Thoracic lordosis also decreases lung volume and increase the deleterious effect of scoliosis on pulmonary function [7-9].

With this background the present study has been designed to evaluate the factors determining the pulmonary function tests in cases of idiopathic paediateric scoliosis. How do the standard clinico-radiological characteristics determine pulmonary functions are yet to be answered. This study will tend to answer it.

Materials and methods

The proposed observational cross sectional study was conducted in the department of Orthopaedic Surgery, King George's Medical University Lucknow. The open ended prospective study had been conducted on children having scoliosis in Paediateric age group and attending our outpatient department during August 2011 to July 2012. Total 33 patients were included in the study as per inclusion-exclusion criteria. The five patients, in the age group of 2 to 6 years who were not able to perform spirometry were excluded from the study. So observation of only 28 children with idiopathic scoliosis were presented. Patients those are aged from 2 years to 16 years of both sexes, having idiopathic scoliosis and patients / attendants giving informed consent were included in the study.[10] Patients who are aged < 2 years and more than 16 years, having secondary scoliosis e.g. post-polio, limb length abnormality, associated neurofibromatosis etc., congenital scoliosis, associated Kyphosis / Lordosis, any significant systemic disease affecting lung functions and patients / attendants not giving informed consent were excluded from the study [11-13].

All the patients included as per above inclusion/exclusion criteria had been subjected to the clinical evaluation using standardized pilot tested protocol to record comprehensively validly and precisely all features of patient demography, clinico-radiological characteristics of scoliosis which can determine pulmonary functions. Pulmonary function was tested at the department of physiology of this university. All the data had been recorded in the enclosed proforma.

The univariate association between characteristics of scoliosis and pulmonary function tests was determined. Those characteristics that are significantly associated with abnormal pulmonary functions in univariate analysis had been used together to develop a multivariate model to predict pulmonary functions. Predicted was validated against observed to determine the power of model to predict correctly. The residual errors had been analysed.

The data was entered in Microsoft Excel Sheet and checked for any inconsistency. The results are presented in percentages, mean (±SD) and minimum – maximum. The categorical/ dichotomous variables are analysed by using Chi-Square/Fisher Exact Test. The two continuous variables are compared by using unpaired/paired t-test. More than two means are compared by using One Way Analysis of Variance (ANOVA). The p-value less than 0.05 is being considered significant. All the analysis is carried out by using SPSS 15.0 version.

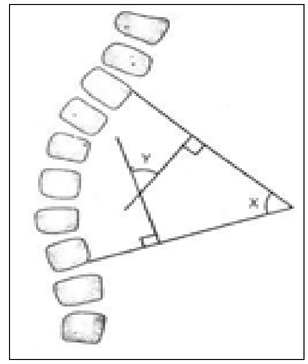

Fig 1: Cobb's method of measuring severity of a curve (Y=angle) [13]

Results and discussion

Total 33 patients were included in the study as per inclusion-exclusion criteria. The five patients, in the age group of 2 to 6 years who were not able to perform spirometry were excluded from the study. So observation of only 28 children with idiopathic scoliosis were presented.

Total 20 out of 28 patients i.e. 71.4% were between 10-16 years, 7 out of 28 patients i.e. 25% were between 6-10 years, and only one was in 2-6 years age i.e. 3.6%. The (mean + SD) age of all the patients was 12.07 (+3.31). Majority of the males (72.7%) and Females (70.6%) patients were in age group 10-16 years. The difference in males and females was insignificant (p=0.71) in all age groups. (Table 1)

Table 1: Distribution of patients by age and sex

Age in years	Male (n=11)		Female (n=17)	
	No.	%	No.	%
02-6	0	0.0	1	5.9
6-10	3	27.3	4	23.5
10-16	8	72.7	12	70.6

Mean (+ SD) 12.07 (+ 3.31)

Table 2 depicts the distribution of anthropometric parameters by age. The overall height (mean) was 138.04 (+20.17) cms and (mean) weight was 32.07 (+10.17) kgs. There was increasing trend in height and weight as age increases.

Table 2: Distribution of patients by anthropometric measurements

Age in years	No. of patients	Height in cms (Mean+SD)	Weight in Kg (Mean+SD)
02-6	1	108.00	15.00
6-10	7	118.00+12.50	21.85+ 8.84
10-16	20	146.55+ 16.04	36.50+ 7.99
Total	28	138.04+ 20.17	32.07+ 10.71

Values in the parenthesis are Min.-max.

Distribution of patients as per clinical parameters is given in the Table 3, Dorsolumbar curve was seen in 17 patients i.e. 60.7% of the patients. Rib hump towards right side was seen in 19 out of 28 cases i.e. 67.9% of the patients and similar observation was found for convexity of curve. Total 9 males out of total 11 males (81.8%) included, were having left Curve i.e. 81.8%, while all females were having predominantly right curve. Clinical correct ability of curve was absent in all the patients. This observation ruled out any functional scoliosis.

Table 3: Distribution of patients as per clinical parameters

S. No.	Parameters	No. (n=28)	%
1	Extent of scoliosis		
	Dorso Cervical	1	3.6
	Dorsal	8	28.6
	Dorsolumbar	17	60.7
	Lumbar	2	7.1
2	Rib hump		
	Left	9	32.1
	Right	19	67.9
3	Convexity of curv		
	Left	9	32.1
	Right	19	67.9
4	Clinical correctability of curve		
	Present	0	0.0
	Absent	28	100.0

Distribution of patients as per radiological parameters studied was presented in the Table 4. Primary type of curve was predominant in all patients and dorsa lumbar as extent of curve was present in 60.7% of the patients. The right side convexity side was seen in 67.9% of the patients i.e. 19 out of 28 patients. The average Cobb's angle was 21.89 (+ 10.37) with range of minimum 15degrees and maximum of 42 degrees. More than 64% i.e. 18 out of 28 cases were in 10-20 degree Cobb's angle group (i.e. mild severity group). Iliac apophysis fusion (Reisser's Sign) was observed in this study. Total 9 cases (32.1%) were in Reisser's grade 11, eight cases (28.6%) in group I, 07 cases (25%) in group III and rest (14.3%) were in group IV. No. child was in group V.

Table 4: Distribution of patients as per radiological parameters

S. No.	Parameters	No. (n=28)	%
1	Type of curve		
	Primary	28	100.0
	Secondary	0	0.0
2	Extent of curve		
	Dorsal cervical	1	3.6
	Dorsal	8	28.6
	Dorsal lumbar	17	60.7
	Lumbar	2	7.1
3	Convexity side		
	Left	9	32.1
	Right	19	67.9
4	Cobb's angle		
	10-20	18	64.3
	20-30	4	14.3
	30-40	4	14.3
	40-50	2	7.1
	Mean +SD (Cobb's angle)21.89+10.37 (15-42 degrees)		
	Iliac apophysis		
5	Grade I	8	28.6
	Grade II	9	32.1
	Grade III	7	25.0
	Grade IV	4	14.3
	Grade V	-	-

The distribution of pulmonary function test – Spirometry is given in the Table 5. The average predicted FEVI was 2.06 (+0.52) and observed was 1.83 (+0.66) the % age observed predicated EFVI was 84.70 (+ 30.09). However, this was statistically insignificant (p>0.05).

The average predicted FVC was 47.09 (+14.86) and observed was 56.65 (+ 24.62). The %age observed predicted FVC was 47.09 (+ 14.79), and observed was 56.65 (+24.62.) The %age observed FVC was 89.85 (+14.79). However, this was statistically nearly significant (p=0.05). The average predicted FEVI/FVC was 90.19 (+ 4.34) and observed was 89.96 (+ 9.26). The %age observed predicted FEVI/FVC was 98.72 (+13.51). However, this was statistically insignificant (p>0.05).

The average predicted PEFR was 4.94 (+1.33) and observed was 4.92 (+1.72). The %age observed predicted PEFR was

88.34 (+37.12). However, this was statistically insignificant (p>0.05.)

Table 5: Distribution of pulmonary function test-Spirometry

Pulmonary function test				
	FEVI	**FEVI/FVC**	**PEFR**	**FVC**
Predicted (Mean+SD)	2.06+0.52	90.19+4.34	4.94+1.33	47.09+14.86
Observed(Mean+SD)	1.83+ 0.66	89.96+9.26	4.92+1.72	56.65+24.62
% observed predicted(Mean+SD)	84.70+30.0	98.72+13.5	88.34+37.8	89.85+14.79
P-value (Predicted vs Observed)	0.12	0.92	0.97	0.05

The comparison of clinical parameters with FEVI is given in the Table 6. No. significant association was observed between predicted and observed FEVI level by clinical parameters.

Table 6: Comparison of clinical parameters with FEVI

Rib hump				
Left (Mean+SD)	1.92+0.70	1.47+0.48	89.33+21.65	0.23
Right	2.09+0.47	1.93+0.67	83.43+32.31	0.27
P-value	0.48	0.13	0.67	
Clinical correctivity of curve				
Present (Mean+SD)	-	-	-	-
Absent (Mean+SD)	2.05+0.52	1.83+0.65	84.69+30.08	0.11
P-value	NA	NA	NA	

The comparison of radiological parameters with FEVI/FVC is given in the Table 7. There was no significant difference between predicted and observed FEVI/FVC and radiological parameters. However, there was significant difference (p=0.04) among Cobb's angles in %observed predicted.

Table 7: Comparison of radiological parameters with FEVI/FVC

Radiological Examination	**FEVI/FVC (Mean+SD)**			
	Predicted	**Observed**	**% Observed predicted**	**p-value**
Type of Curve all	**90.19+4.39**	**89.96+9.26**	**98.71+13.51**	**0.78**
Primary (Mean+SD)				
Extent of Curve				
Dorsal cervical	92.00+3.61	79.00+18.52	85.33+20.21	0.29
Dorsal (Mean+SD)	9.89+4.01	88.51+6.42	98.60+10.36	0.67
Dorsal Lumbar (Mean+SD)	89.85+4.69	91.69+7.51	100.12+12.76	0.89
Lumbar (Mean+SD)	88.74+6.03	94.44+6.28	106.50+14.85	0.11
P-value	0.83	0.14	0.29	
Convexity side				
Left (Mean+SD)	90.75+3.67	90.43+5.60	96.16+11.37	0.98
Right (Mean+SD)	90.03+4.62	89.83+10.13	99.41+14.19	0.94
P-value	0.73	0.89	0.61	
Cobb's angle				
10-20 ((Mean+SD)	90.66+2.95	87.27+10.07	95.22+12.55	0.56
20-30 (Mean+SD)	86.35+3.76	95.34+6.95	112.25+9.53	0.34
30-40 (Mean+SD)	91.24+8.82	95.14+4.98	105.02+14.69	0.45
40-50 (Mean+SD)	91.50+4.94	93.00+1.23	90.50+9.19	0.45
P-value	0.31	0.23	0.04*	
Iliac apophysis				
Grade I (Mean+SD)	88.98+4.87	93.43+4.89	105.2+11.35	0.34
Grade II (Mean+SD)	90.60+ 3.12	87.2+13.98	93.66+ 16.70	0.32
Grade III (Mean+SD)	92.57+4.90	85.53+2.90	93.56+3.91	0.54
Grade IV (Mean+SD)	87.48+4.03	96.95+3.50	105.50+16.19	0.45
Grade V	-	-	-	-
p-value	0.23	0.11	0.16	

Conclusions

Study concluded that clinic-radiological factors have an effect on pulmonary function test in scoliosis patients of paediatric age group. There is significant reduction in FVC and other parameters of PFT in Idiopathic scoliosis patients of paediatric age group [14, 15].

FVC tells about the restrictive lung disease and is the most significant parameter. Cardiopulmonary status of the patient is an important and vital parameter in the follow up of natural history of scoliosis, as it may affect the overall performance of the individual affected by this condition.

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