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ORIGINAL ARTICLE

Frequency of Deranged Pulmonary Function Tests in patients with Adolescent Idiopathic Scoliosis

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ABSTRACT

Objectives: The clinical study was carried out to establish the frequency of deranged pulmonary function tests (PFTs) in patients suffering from adolescent idiopathic scoliosis (AIS).

Methodology: All the patients consulting to the OPD of the department with scoliosis were gone through the diagnosis of AIS as per operational definition and patients complying the criteria of inclusion were included in the study. A comprehensive clinical history was obtained succeeded by detailed bodily and systemic examination. Cobb angle was measured using standard technique and type of scoliosis was classed according to standard Lenke Classification system. All patients were then sent to pulmonology department for assessment of derangement in pulmonary function tests (PFTs) and derangement in PFTs was defined as per operational definitions.

Results: Out of 88 patients, 76.1% were males and 23.9% were females. Mean age was 13.39 ± 1.86 years and mean Cobb angle was 45.03 ± 16.2 ºs. Maximum patients were of 10-12 years age i.e. 35.2%. Most patients (34.1%) were observed with 41-55 º Cobb angles. 30.7% patients were with Type 2 curve. 38.6% patients were observed with moderately severe deformity, followed by 28.4% patients with moderate severity. The curve was structural in 86.4% patients while non-structural in 13.6% patients. Deranged PFTs were observed in total 64.8% patients.

Conclusion: Pulmonary Function Tests (PFTs) like FVC and FEV1 are highly associated with AIS and preoperative PFTs are very helpful in planning and management of the surgery of patients with scoliosis.

Keywords: AIS-Adolescent idiopathic scoliosis, Pulmonary function tests, FVC-Forced vital capacity, Cobb Angle.

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INTRODUCTION

Scoliosis is a musculoskeletal disease and is a general terminology used for a group of illnesses involving shape and position of spine, thorax and back resulting from alteration in composition. [1]

An observable lateral bending is its characteristic having direct effect on chest cavity. [2]

The Scoliosis Research Society (SRS) confirms the diagnosis if the Cobb's angle is 10 º or greater and there is significant presence of axial rotation.[3] This will be diagnosed as idiopathic scoliosis if the causes of the deformity are not known.[4]

Scoliosis is a three-dimensional spinal deformity that results in an abnormal curvature of the spine

across the frontal, sagittal, and axial planes. This misalignment of the thoracic vertebrae can reduce the volume of the thoracic cavity, which may adversely influence pulmonary function.[5]

There is a multiplication of alveoli alongside hypertrophy during lung development. A rapid rate of this multiplication is observed up to the 4 years of age while the faster rate of hypertrophy is observed up to the age of 8 years, however, this hypertrophy continues up to 25 years of age. [6]

Infantile scoliosis appearing before 3 years of age is considered as to be severely affected because decreased numbers of alveoli are developed. This is also affected in juvenile scoliosis with decreased alveolar hypotrophy. In idiopathic scoliosis, lungs are nearly fully developed, by the time when scoliosis is developed. It was consequently assumed that there will be no impact on function of lungs.[7]

Updated reports, however, share that in children suffering from idiopathic scoliosis, thoracic cage is still narrower than the normal children. Similar to that in infantile and juvenile scoliosis, this narrower space also affects the lung growth in these children, although to relatively lesser extent. Mechanics of respiratory muscle are poor in children with idiopathic scoliosis due to this deformity leading to a restrictive function of lung.[8]

Prevalence of scoliosis is 0.3 to 15.3% of the population while the prevalence of AIS is reported from 0.47% to 5.2%. Idiopathic scoliosis is about in 85% of the total cases of scoliosis that is recognized as a systemic scoliosis but without any identifiable reason. The amount and seriousness of spinal deformity is higher in females compared to males.[8,9,10]

There is back pain together with health related issues for these sufferers affecting the quality of living. They also suffer from cosmetic and psychosocial issues. Besides these, there is disturbed cardiopulmonary function which results in increased mortality due to these severe thoracic curves.[11,12]

Hence this advancement of scoliosis of the thoracic cavity can give rise to deteriorated lung function.[13] In patients where scoliosis started at younger age and remained untreated, there was high scoliotic angle, low vital capacity and respiratory failure. So untreated scoliotic patients have increased danger of ventilatory failure and therefore pre-mature demise, but studies have not clearly demonstrated this increased mortality in adolescent patients suffering from idiopathic scoliosis.[14]

In general, there is consideration of researchers on this spinal deformity and it is accounted for to impact pneumonic capability however evaluation of lungs capabilities in such manner is less engaged. These lungs function can also be impaired in result of biochemical changes of thoracic cage and the spine.[13-15]

Special focus is therefore required in scoliotic patients particularly with the chest curvatures to anticipate the interference with the pulmonary functions.

As only few studies in patients with AIS regarding their pulmonary function are available, our study focused on adolescent patients having idiopathic thoracic or thoracolumbar scoliosis with a significant.

Keeping in mind that for AIS patient's chest problems are very important if they are under plan for a surgery as they can't tolerate surgical stress with compromised pulmonary functions, the study will help to provide data based on relation between severity or type of curves and derangement of pulmonary function tests.

These results will be also helpful while updating the guidelines to provide extra care and also suggesting mode of anesthesia for these patients like Total Intravenous Anesthesia (TIVA).

Study design: The study conducted was cross sectional by design.

Place and Duration of the Study: This study spanned about 6 months at the Orthopedic and Spine Surgery department, Khyber Teaching Hospital, Peshawar, Pakistan from 18-07-2020 to 18-01-2021.

METHODOLOGY

This study spanned about 6 months at the department of orthopedic surgery, Khyber Teaching Hospital, Peshawar, Pakistan from 18-07-2020 to 18-01-2021. The Consecutive non-probability sampling technique was adopted. All the patient consulting to the OPD of the department with scoliosis were gone through the diagnosis of AIS as per operational definition and patients meeting the required criteria of inclusion were made part of this study.

A comprehensive clinical history was obtained succeeded by detailed bodily and systemic examination. Standard antero-posterior, horizontal and lateral bending X-Rays and MRI of the whole spine were done for all the cases. Exclusions were done on the basis of history, physical exam and radiography.

The inclusion criteria were set as, all the patients suffering from AIS having Cobb's angle 10 º or greater on PA plain radiograph with age range of 10-16 years.

Exclusion criteria was set as all those patients with other congenital spinal deformities, muscular dystrophies and neurological/neuromuscular scoliosis assessed clinically and by nerve conduction studies, patients having previous history of spine surgery evident from clinical examination, x-rays and past clinical data as the previously described disorders might have acted as confounders and their inclusion in the study sample would introduce bias in the study result.

A total of 88 patients were enrolled in the study. For all patients who were eligible for inclusion in study, Cobb angle was measured using standard technique. Type of scoliosis was classed according to standard Lenke Classification system. All patients were then sent to pulmonology department for assessment pulmonary functions. Standard Spirometry was done and FVC-Forced Vital capacity as well as FEV_1-Forced Expiratory Volume in 1 second was calculated and derangement in PFTs was measured.

Structurality of curved was also important and was actually a measure of flexibility of curve. A curved was structural (rigid) if its Cobb angle did not fall below 25 º on bending poster anterior X-rays as compared to standard erect posterior anterior Rays. If Cobb angle falls below 25 º on bending radiographs, the curve was regarded as non-structural (flexible).

Data collection and analysis was done using statistical software SPSS version 21. Quantitative variables including age and Cobb's angle were assessed using Mean ±Standard Deviation. Qualitative variables including gender, Lenke type, deformity severity and PFTs were analyzed using Frequency and Percentage. Deranged PFTs were stratified among age, gender, Cobb angle, Lenke type and deformity severity group to assess heterogeneity of effect. Other effect modifiers such as Curve Structurality were managed by stratification. After stratification, chi square test was carried out keeping P value equal or less than 0.05.

Written consent was taken for inclusion in the study from all patients.

RESULTS

A total of 88 patients were included in the study. The age of the patients ranged from 10 to 16 years. The Mean ±SD calculated for age and Cobb angle are shown in Table-I.

Male gender was dominant in this study. The gender wise frequency and percentage are given in table-II.

Similarly, patients were grouped on the basis of Cobb angle. More patients were observed with 41–55 º Cobb angles, followed patients with 26-40 º Cobb angles, patients with 56-70 º Cobb angles and patients with 10-25 º Cobb angles as shown in Table-III.

According to Lenke Classification, most patients were observed with Type 2 curve followed by patients with Type 5, Type 6, Type 4, Type 3 curve and least number of patients with Type 1 curve as shown in Table-IV.

Table-I: Mean ±Standard Deviation of patients in accordance with age and Cobb angle: n=88

	Demography	Mean ±Standard Deviation
1	Age (weeks)	13.39±1.86
2	Cobb Angle	45.03±16.2

Table-II: Incidence and % of patients as per gender n=88

Gender	Frequencies	%(Percentages)
Male	67	76.1%
Female	21	23.9%
Total	88	100%

Table-III: Details of patient's distribution as per Cobb angle. n=88

Cobb Angle (Degree^{O})	Frequency	Percentage
10-25	12	13.6%
26-40	25	28.4%
41-55	30	34.1%
56-70	21	23.9%
Total	88	100%

Table-IV: Patient's distribution as per Lenke Type. n=88

Lenke Type	Frequency	Percentage
Type-1	8	9.1%
Type-2	27	30.7%
Type-3	10	11.4%
Type-4	11	12.5%
Type-5	20	22.7%
Type-6	12	13.6%
Total	88	100%

Distributing the patients as per deformity severity, most patients were observed with moderately severe deformity, followed by patients with moderate severity, patients with severe

deformity and patients with mild deformity as shown in Table-V.

Table-V: Patient's distribution as per deformity severity. n=88

Deformity Severity	Frequency	Percentage
Mild	12	13.6%
Moderate	25	28.4%
Moderately Severe	34	36.6%
Severe	17	19.3%
Total	88	100%

The distribution among patients as per curve structurality showed that most patients were with structural deformity as shown in Table-VI.

Table-VI: Frequency and percentage of curve Structurality. n=88

	Frequency	Percentage
Structural	76	86.4%
Non-Structural	12	13.6%
Total	88	100%

Most of the patients were found with deranged PFTs in the study as shown in Table-VII.

Table-VII: Frequency and Percentage of patients with deranged PFTs n=88

Deranged PFTs	Frequency	Percentage
Yes	57	64.8%
No	31	35.2%
Total	88	100%

DISCUSSION

Idiopathic scoliosis is a disorder that results when the vertebrae are rotated or displaced laterally during rapid somatic development period. Previous studies have mentioned the decline in pulmonary functions that are faced by this spinal deformity. This spinal deformity results in decrease in pulmonary functions and is said to be directly related to severity of these deformities.[16,17,18,19,20,21,22] An increased work load of breathing, decreased chest wall and lung compliance is faced by the patient during rest, exercise and even in sleep. As the severity progresses, it may start development of respiratory failure and pulmonary hypertension.

The importance of this correlation also emerges from the fact that these patients with deranged pulmonary function tests may need the postoperative ventilation. In a study conducted by Issac E et al.[7], 2 patients with infantile scoliosis and a considerable number of cases with juvenile scoliosis were reported to need postoperative ventilation. This may be the result of lung hypoplasia during rapid lung growth period faced due to thoracic deformity.

In the study conducted by Udink ten Cate FE *et al*.[24], an increased number of patients with Neuromuscular Scoliosis required extended mechanical ventilation. Compromised pre-operative lung function was the major risk factor among these patients.

Increased frequency of post-operative complications and prolonged care at ICU was also reported in corrective surgery of NMS patients.[25]

Effect of PFT in the postoperative period and it's relation to post-operative ventilatory support after surgical intervention for scoliosis was also evaluated by Issac E et al.[7] They reported that differences in the variables of spirometry were statistically significant between 2 groups including FEV1% and FVC%. Patients with Forced Expiratory Volume in 1sec <37.99 and Forced Vital Capacity <38.23 required mechanical ventilatory support.

Almenrader and Patel also reported that patients having pre-operative Forced Vital Capacity <30% showed higher requirement for post-operative ventilatory support.[26]

Yuan *et al*. and Gibson both reported in their studies that FEV1% <40% leads to postoperative pulmonary complications and longer duration of mechanical ventilation.[27,28]

In this study, we kept all the epidemiological and anatomical a record of AIS patients. The consequences of progression of AIS on pulmonary function are focused in detail. The lung function testing (PFTs) that included FVC and FEV1, as well as the Cobb angle, deformity severity, Lenke Type, curve structurality are also considered.

In our study, Means ± Standard Deviations calculated for age and Cobb angle were 13.39 ± 1.86 years and 45.03 ±16.2 º, respectively as shown in Table-I.

The study done by Issac [7]reported more prevalence of AIS in girls (83.3%) compared to boys. Konieczny MR[9] also reported that same but in our study the reported patients were predominantly males (76.1%) as shown in Table-II.

More patients were observed with 41-55 º Cobb angles, followed patients with 26-40 º Cobb angles (Table-III). According to Lenke Classification, most patients were observed with Type 2 curve (30.7%) followed by patients with Type 5 curve (22.7%) as shown in Table-IV.

Most patients (38.6%) were observed with moderately severe deformity, followed by patients with moderate severity (28.4%) as shown in Table-V. The curve was structural in 86.4% patients while non-structural in 13.6% patients as shown in Table-VI.

Coming to the primary outcome of the study, deranged PFTs were observed in majority of the patients that is 57 patients out of 88 patients (64.8%) while it was not observed in 31 patients (35.2%) as per results shown in Table-VII.

These results are in line as mentioned in studies done previously over the topic.

Tsiligiannis T[8] mentioned that idiopathic scoliosis has severe irreversible effects on pulmonary functions which may not be clinically evident until a significant change has already developed in the lung functions. He therefore emphasized on early recognition and regular evaluation of these lung functions.

Idiopathic scoliosis is a condition that weakens the thoracic cage and causes potential and long-lasting effects on the respiration. Abdelaal AAM and coworkers evaluated the respiratory function and functional exertion capacity in the mild AIS. They studied Forced Vital Capacity, Forced Expiratory Volume, The ratio of FEV and FVC, Maximal Voluntary Ventilation and 6-Minute Walk Test and showed significant differences in all these parameters. They concluded that there is early start of minimal respiratory and functional constraints in Adolescent Idiopathic Scoliosis.[23]

Bashir K et al., shared on the basis of their study that pulmonary symptoms may not appear clinically unless there are significant and long-standing alterations in the pulmonary function. It was advised to recognize the condition earlier and to perform regular lung function test in these AIS patients.[29] Among other research available on the topic, Wang et al. showed in their prospective study that in patients where there was preoperative FVC impairment (FVC% predicted < 80%), restrictive ventilation was 62.5%. [30]

Deranged PFTs were stratified with respect to gender; wherein deranged PFTs in males were observed in 47.7% patients while in 17% female patients. These results are different from retrospective analysis by Issac E et al. that showed that scoliosis predominantly affects females.[7]

Similarly, deranged PFTs were stratified with respect to Cobb angles; wherein most patients with deranged PFTs were observed in 41-55 º Cobb angle, followed by 26-40 º Cobb angel.

In all the results discussed above we didn't find any significant impact of age, gender, Lenke type, deformity severity and curve structurality on PFT however there was significant effect of Cobb angle on PFTs. We can compare these results with the finding of Rekha BY et al., [26] who worked on analysis of lung function in thoracic AIS. They conducted spirometry and evaluated TLC, FVC and FEV_1 for evaluation of pulmonary functions. The results showed that only number of vertebrae involved had significant correlation with decrease in lung functions. They therefore concluded that respiratory functions are only significantly affected in cases where more than seven vertebrae are involved and evaluation must be done before surgery. These results are in difference in comparison to our results in a way that they showed that Cobb angle didn't predict lung functions.

As mentioned earlier, there is decrease in pulmonary function with spinal deformities. Researchers have majorly discussed the outcomes of radiographic variables of spinal deformity and its relation to lung function, such as MT-Cobb, Main Thoracic-Apical Vertebral Translation, Thoracic Kyphosis, and Main Thoracic-Rib Hump. However, very few studies are present on the outcomes of other radiographic variables of spinal deformities and lung function that includes Main Thoracic-Apical Vertebral Body-to-Rib Ratio, Main Thoracic-Flexibility Index, and Main Thoracic-Thoracic Depth.

We also studied the anatomical and epidemiological features of adolescent idiopathic scoliosis and observed the patho-physiology and outcomes of idiopathic scoliosis on important pulmonary functions. This pulmonary function testing (PFTs) included FVC and FEV1, as well as the Cobb angle, deformity severity, Lenke type and curve structurality. These results will help the researchers in future to study the correlation between AIS and PFTs and also the surgeons planning for these surgeries in future.

Limitations of our study includes the reliability of results reported for PFTs because these results may be influenced by standard requirement of the observer, environmental factors and subjective/objectives features of the patient involved. The outcomes of the PFTs were also un-adjusted for the decrease in height because of scoliotic deformity. The sample size in this research was small-scale and therefore may have a statistical effect. Therefore, it is recommended that multi-center clinical research should be conducted with expanded sample size to further validate the research.

CONCLUSION

Adolescent Idiopathic Scoliosis is a prevalent condition and the prevalence and curve deformity severity are higher for boys than for girls in our region, as well as the male to female ratio increases with increasing age of the children. Pulmonary Function Tests (PFTs) like FVC and FEV1 are highly associated with AIS and preoperative PFTs are very helpful in planning and management of the surgery of patients with scoliosis.

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