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ORIGINAL ARTICLE

Etiology, Diagnosis, and Treatment in Childhood Atelectasis

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Abstract

Introduction: Atelectasis is the loss of lung volume secondary to collapse. Narrow and collapsible airways and underlying chronic diseases facilitate the development of atelectasis in children. Since atelectasis is an important cause of morbidity and mortality in children, early diagnosis and treatment are of great importance.

Methods: Thirty-six patients who were followed up in the pediatric service and pediatric intensive care unit of our clinic between December 1, 2018, and June 1, 2019, and were diagnosed radiologically with atelectasis were evaluated retrospectively.

Results: The median age was 1.85 years (1.0–7.37). The most common cause for hospitalization was pneumonia (n=30, 83%). Except for two patients, all patients had an underlying disease that increased the risk of atelectasis. Neurological diseases were the most common diseases among the underlying diseases (n=12, 36%). For the treatment, 4 (11.1%) patients received chest physiotherapy, 19 (52.7%) patients received nebulized medications, and chest physiotherapy, and 13 (36.1%) patients received positive end-expiratory pressure support in addition to these treatments. The frequency of atelectasis in more than one localization was higher in children with the neurological disease than in other patients (n=7, [54%] vs. n=3, [13%]; p=0.018). In patients with atelectasis in more than one localization, the duration of hospitalization was longer (median 12.5 days [9.5–16.75] vs. 19 days [13–22.75]; p=0.034).

Discussion and Conclusion: Atelectasis is common in hospitalized children with an underlying disease. In the presence of pathological respiratory symptoms and signs, atelectasis should be kept in mind, and treatment should be started early.

Keywords: Atelectasis; child; pulmonology.

Atelectasis is the volume loss that develops due to collapse of a segment, lobe, or the whole of the lung parenchyma[1]. Atelectasis can develop as basically a result of increased surface tension due to airway obstruction, parenchymal compression, surfactant deficiency, or surfactant dysfunction. Atelectasis occurs more easily in children because their airway is narrow, prone to collapse, and collateral ventilation is seen less frequently[2].

Underlying causes such as neurological diseases, cystic fibrosis, and primary ciliary dyskinesia, chronic lung diseases such as asthma, and airway malacia may facilitate the development of atelectasis. Since atelectasis is an important

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cause of morbidity and mortality in children with underlying diseases such as neurological diseases, early diagnosis and treatment are of great importance[3]. There are very few studies in the literature evaluating atelectasis in children, and there is no study on atelectasis detected in hospitalized children. In this study, clinical and demographic characteristics and factors associated with atelectasis were evaluated in pediatric patients with atelectasis who were hospitalized in the ward and intensive care unit of a tertiary pediatric clinic.

Materials and Methods

A total of 36 patients who were followed up in the pediatric service and pediatric intensive care unit of our clinic between December 1, 2018, and June 1, 2019, and who were found to have atelectasis radiologically were evaluated retrospectively. Clinical and demographic data of the patients were recorded. The hospitalization causes and underlying diseases of the patients were determined. Posteroanterior and lateral chest radiographs were obtained in all patients for atelectasis diagnosis. Patients who could not be diagnosed with chest radiography were also evaluated with thoracic tomography and ultrasonography. Radiological localization (upper, middle, lower, and multiple zones), extent of the involved area (segmental and subsegmental, lobar, and total), and post-treatment radiological response were evaluated by the same pediatric radiologist. Regression of respiratory signs and symptoms in patients was defined as clinical response, and regression in radiological findings was defined as radiological response. Flexible bronchoscopy was performed in patients who did not develop a clinical or radiological response. Factors affecting clinical and radiological response and length of stay were investigated. SPSS 23 program was used for statistical analysis. Categorical measurements were recorded as numbers and percentages; and among the numerical measurements, data which showed parametric distribution as mean and standard deviation and data which showed non-parametric distribution as median (25^{th}–75^{th} percentile). Subgroup analysis was performed by dividing the patients' hospitalization, clinical, and radiological response times into two subgroups, as long and short, according to median values. Mann–Whitney U-test and Chi-square analysis were performed to evaluate the relationships between data.

The study was conducted in accordance with good clinical practice and the Declaration of Helsinki. The families were informed about the study and their consent was obtained. The study was approved by the ethics committee of our hospital (Ethics Committee approval number: 0.01/171).

Results

About 50% of the patients were females. The median age was 1.85 years (1.0–7.37). Thirty patients were hospitalized for pneumonia (83%), two patients for neurological causes (6%), and two patients for asthma attack (6%). Except for two patients, all patients had an underlying disease that increased the risk of atelectasis. While five (14%) patients had a single underlying disease, 29 patients (81%) had more than one underlying disease. While the most common underlying diseases were neurological diseases (n=12, 36%), bronchopulmonary dysplasia and anatomical airway abnormalities (malacia, intrabronchial obstruction, and anatomical variation) were in the second place (n=6, 17%), and asthma and congenital heart diseases were at the third place (n=5, 14%). Fourteen of our patients (38.9%) had cough, nine (25%) had tachypnea, nine (25%) had low saturation, and three (4%) had pathological auscultation findings in respiratory system examination. General characteristics of our patients are shown in Table 1.

In patients who could not be diagnosed by chest radiography or who did not respond to treatment appropriately, tho-

Table 1. General characteristics of our patients

	n (%)
Sex, male	18 (50)
Age (years)	1.85 (1.0–7.37)
Comorbidity	
Neurological diseases	12 (36)
Anatomical airway abnormalities	6 (17)
Bronchopulmonary dysplasia	6 (17)
Asthma	5 (14)
Congenital heart disease	5 (14)
Airway malacia	4 (11.1)
Symptom	
Cough	14 (38.9)
Tachypnea	9 (25)
Hypoxia	9 (25)
Auscultation finding	3 (10)
Hypoxia and tachypnea	1 (2.8)
Oxygen saturation (%)	93.9±0.52
Reason for hospitalization n (%)	
Pneumonia	30 (83.5)
Neurological causes	2 (5.5)
Asthma attack	2 (5.5)
Other	2 (5.5)
Clinical response time, days (25–75. percentile)	5 (4–7)
Length of stay, days (25–75. percentile)	13 (11–19)
Radiological response time, days (25–75. percentile)	9 (5.5–13)

racic ultrasonography (n=5), and thorax tomography (n=6) were additionally performed during follow-up. The diagnosis was made by thoracic tomography in six (17%) patients. The radiological findings of our patients are seen in Table 2.

In the treatment, chest physiotherapy was applied to four patients (11.1%), chest physiotherapy with nebulized drug administration was applied to 19 patients (12 patients (33.3%) received nebulized salbutamol, five patients (13.9%) nebulized hypertonic saline, two patients (5.6%) nebulized dornase alfa, and 13 patients (36.1%) received positive end-expiratory pressure (PEEP) support in addition to chest physiotherapy and nebulized treatments. While 12 patients (33.3%) did not need respiratory support, seven (19.4%) patients received O_2 support. Non-invasive ventilation was applied to seven patients (19.4%) and invasive ventilation was applied to ten patients (11.1%). The median time for clinical response to treatment was 5 days (4–7), while the median length of stay was 13 days (11–19). Clinical response was obtained in all patients except one. One patient, who did not respond clinically, died due to complications due to the underlying congenital heart disease. Median radiological response time was 9 days (5.5–13). Radiological response was obtained in 26 patients (72.2%), and no radiological response was obtained in ten patients (27.8%).

Flexible bronchoscopy was performed in ten patients whose clinical and radiological findings persisted despite the treatment. Of ten patients, airway malacia was detected in four, congenital bronchial anomaly in two, carcinoid tumor in one patient, and increased purulent secretion was detected in one patient; bronchoscopy was normal in two patients.

Considering the factors affecting the atelectasis detected in our patients, the prevalence of atelectasis in more than one location in children with neurological disease was higher than in other patients (n=7 [54%] vs. n=3 [13%]; p=0.018).

Table 2. Radiological findings of the patients

	n (%)
Radiological localization	
Upper lobe/zone	12 (33.3)
Middle lobe/zone	2 (5.6)
Lower lobe/zone	12 (33.3)
Multiple localization	10 (27.8)
Radiological extent	
Subsegmental/segmental	22 (61.1)
Lobar	12 (33.3)
Total	2 (5.6)

The length of stay at hospital of the children with neurological diseases was also longer than the others (median: 16 days [13.25–21.75] vs. 12 days [9.5–16.75]; p=0.005).

The length of stay was found to be longer in patients with atelectasis in more than one location (median: 12.5 days [9.5–16.75] vs. 19 days [13–22.75]; p=0.034).

While radiological improvement was observed in 18 (86%) of the patients with subsegmental/segmental atelectasis and 8 (62%) of the lobar atelectasis, there was no radiological improvement in two (100%) patients with total atelectasis (p=0.02).

While the duration to receive clinical response was long in all patients who received only chest physiotherapy, it was observed that the clinical response time was short in 63% of the patients who received additional nebulized drug with chest physiotherapy. There was no correlation between radiological response and radiological recovery times according to the treatments given.

Factors associated with clinical response, length of stay and radiological response are shown in Table 3.

Discussion

Atelectasis develops more easily in children compared to adults due to narrow airways and low lung compliance. In addition to pulmonary causes due to obstruction of the bronchial lumen and increased alveolar surface tension, many extrapulmonary reasons such as external compression of the airways and lung parenchyma or neuromuscular diseases may cause the development of atelectasis.

Clinically, symptoms and signs vary depending on the underlying cause and the extent of atelectasis. In treatment, while older children with stable clinical condition with no respiratory failure are followed up on an outpatient basis, young children with signs of respiratory failure should be hospitalized[2,3]. In our study, most of our patients were diagnosed with atelectasis during the course of pneumonia, and it was found that the length of stay was longer especially in children with underlying diseases such as neurological diseases.

Diseases that cause airway inflammation such as pneumonia and asthma cause bronchial collapse and atelectasis by causing increased bronchial secretions, mucosal edema, contraction of smooth muscles, damage of bronchial epithelial cells, and impaired cilia functions[4]. About 83% of our patients who were followed up in the ward and were found to have atelectasis, had pneumonia. In a study conducted by Şişmanlar et al.[5] among patients who applied to the pediatric pulmonology outpatient clinic, pneumo-

Table 3. Factors affecting clinical response, length of stay, and radiological response in patients

	Clinical response			Length of stay			Radiological response		
	Short	Long	P	Short	Long	P	Short	Long	P
Age, n (%)									
<1	5 (36)	9 (64)	0.50	5 (36)	9 (64)	0.55	7 (50)	7 (50)	0.043
>1	11 (50)	11 (50)		10 (45)	12 (54)		4 (18)	18 (82)	
Comorbidity, n (%)									
1	4 (57)	3 (43)	0.67	3 (43)	4 (57)	0.94	4 (57)	3 (43)	0.089
>1	12 (41)	17 (59)		12 (41)	17 (59)		7 (24)	22 (76)	
O_2 saturation, n (%)									
O_2, ≥%94	8 (47)	9 (53)	0.80	11 (65)	6 (35)	0.004	5 (29)	12 (71)	0.800
O_2, < %94	8 (44)	10 (56)		3 (17)	15 (83)		6 (33)	12 (67)	
Radiological involvement, n (%)									
Subsegmental/segmental atelectasis	9 (45)	11 (55)	0.18	8 (40)	12 (60)	0.463	9 (45)	11 (55)	0.040
Lobar atelectasis	4 (31)	9 (69)		6 (46)	7 (54)		1 (8)	12 (92)	
Total atelectasis	1 (50)	1 (50)		0 (0)	2 (100)		0 (0)	2 (100)	
Treatment, n (%)									
Chest physiotherapy	0 (0)	4 (100)	0.032	1 (25)	3 (75)	0.002	1 (25)	3 (75)	0.967
Chest physiotherapy+nebule	12 (63)	7 (37)		13 (68)	6 (32)		6 (32)	13 (68)	
PEEP	4 (31)	9 (69)		1 (8)	12 (92)		4 (31)	9 (69)	

PEEP: Positive end-expiratory pressure.

nia was found in 49% of the patients with atelectasis. In asthma, the risk of inflammation-related atelectasis, especially middle lobe syndrome, is increased. In a study investigating the cases presenting with right middle lobe syndrome, 23% of the patients were diagnosed with asthma[6]. In another study evaluating patients with atelectasis, the frequency of asthma was found to be 12%[5]. In our study, the rate of asthma in patients with atelectasis requiring hospitalization was found to be 6%.

Underlying diseases facilitate the development of atelectasis. In cystic fibrosis and primary ciliary dyskinesia, reduced mucociliary clearance and external compression of the bronchial lumen, and in tracheobronchomalacia, anatomical narrowing of the bronchial lumen increases the risk of atelectasis. Decreased muscle strength and chest wall compliance and weak cough reflex cause in neurological diseases cause non-discharge of respiratory tract secretions, so pneumonia and atelectasis are common in these patients[4]. In a study, all children with neurological diseases and hospitalized in the service were investigated for the presence of atelectasis, and it was shown that 55% of the patients had atelectasis and atelectasis was mostly localized in the lower lobes (59%). In addition, it was found that 13% of the patients had atelectasis in more than one area[7]. In our study, it was found that 36% of the patients had an underlying neurological disease. While atelectasis is found mostly in the upper and middle zones in those without neurological diseases, 46% of those with neurological diseases have atelectasis in the lower lobes and 53% in more than one area. The hospitalization periods of children with neurological diseases were found to be longer than other patients. In children with neurological diseases, in addition to insufficient clearance of airway secretions, accompanying swallowing difficulties and recurrent aspiration, deformities such as scoliosis may lead to a more severe course of respiratory problems and a longer recovery period in patients.

Symptoms in atelectasis vary depending on the underlying cause and the extent of involvement. Cough, wheezing, chest pain, tachypnea, dyspnea, cyanosis, or decreased lung sounds are of the main symptoms and signs[1]. The most common symptom indicating the development of atelectasis in our patients was cough (39%). In the studies conducted in the literature, it was found that 70% of the cases with atelectasis presented with cough, while cough was observed in all asthmatic patients with right middle lobe syndrome[8].

The most widely used method in diagnosis is anteroposterior chest radiography. Increased density in the atelectatic

area, displacement of fissures, ipsilateral elevation in the diaphragm, displacement in the mediastinum, aggregation of vessels, and increased compensatory aeration in other lobes can be seen[9]. In our study, 83% of the patients were diagnosed with atelectasis by anteroposterior chest radiography, while six (17%) patients were diagnosed with computed tomography. In a study investigating the right middle lobe syndrome in patients with chronic cough, chest X-ray was diagnostic at a rate of 55%, while in the study conducted by Şişmanlar et al.[5], 76% of the patients were diagnosed with anteroposterior chest radiography.

Treatment of the underlying disease and chest physiotherapy form the basis of atelectasis treatment. In addition, the addition of salbutamol nebules to chest physiotherapy increases mucociliary functions, and the addition of mucolytic treatments such as hypertonic saline and dornase alfa increases mucus drainage and accelerates the resorption of atelectasis[1,4]. Depending on the underlying disease, the use of auxiliary devices such as mechanical insufflation-exsufflation, high-frequency chest wall oscillation, and intrapulmonary percussive ventilation also increases the effectiveness of physiotherapy[10,11]. In addition, non-invasive ventilation and PEEP can prevent airways and alveolar collapse[12]. Although positive results have been shown in the studies regarding the additional treatments given as an aid to chest physiotherapy, there are no guidelines containing definitive recommendations on this issue. While four of our patients received only conventional chest physiotherapy, 19 patients received nebulized bronchodilator and mucolytic therapy in addition to chest physiotherapy. Clinical improvement was faster and hospitalization period was shorter in our patients who received nebulized treatments together with conventional chest physiotherapy. Non-invasive ventilation therapy was initiated in seven patients due to atelectasis. Six of the patients who received invasive ventilation were intubated patients in the intensive care unit. Four patients were receiving home ventilation with tracheostomy. Since non-invasive ventilation treatment was started later in our treatment protocol and our patient group was small, the effect of this treatment on clinical response and length of stay could not be evaluated. No relationship was found between the treatments initiated and radiological improvement.

Bronchoscopy is very important in the diagnosis and treatment of atelectasis. Diagnosis of foreign bodies and anatomical anomalies, removal of mucus plugs with therapeutic lavage and aspiration, and drug applications such as dornase alfa and surfactant can be performed with bronchoscopy in recurrent and persistent atelectasis. Bronchoscopy is also important for the prevention of late complications such as bronchiectasis in persistent and recurrent atelectasis[4]. In our study, flexible bronchoscopy was performed in ten patients (27%) who did not respond clinically and radiologically. Bronchoscopy was diagnostic in eight patients. Therapeutic lavage was performed by clearing bronchial secretions in five patients. In a study evaluating the results of flexible bronchoscopy in patients with persistent atelectasis, airway anomalies, primarily tracheomalacia, were found as the cause of atelectasis in 46% of 56 patients, and mucus plugs in 29%[13]. In this study, it was observed that atelectasis regressed after lavage in patients with mucus plugs.

There is no specific radiological scoring system in atelectasis. In the literature, some scoring systems have been used according to the localization at the chest radiograph, extent of involvement or the measurement of the maximum thickness in the area of atelectasis[14,15]. In our study, localization and extent of involvement were evaluated using chest radiographs of the patients. In our patients, atelectasis was seen mostly in the upper (33%) and lower zones (33%). About 28% of the patients had atelectasis at multiple localizations. Patients with atelectasis in more than one location were found to stay longer at hospital. Atelectasis is mostly seen in lower lobes and multiple localizations in patients with neurological diseases[16,17]. In our study, as neurological diseases were the most common underlying diseases, our results were consistent with the literature.

The median radiological response time in our study was 9 days. In a study comparing the use of dornase alfa and hypertonic saline in atelectasis in newborns in the literature, the radiological response time was found to be 3 and 4 days in the two groups, respectively[18]. In a study conducted in 27 asthmatic patients with middle lobe syndrome, radiological response was obtained on the 13th day in 40% of patients with an average age of 7[8]. In our study, this difference in radiological response time was thought to be due to age, since the radiological response time was found to be long in children older than 1 year. However, there is no study evaluating age-related radiological responses in the literature.

In conclusion, our study is the first study evaluating the patients who were hospitalized in the pediatric service and intensive care unit and found to have atelectasis. Respiratory complications are an important cause of morbidity and mortality in children with underlying diseases that may predispose to atelectasis, especially neurological diseases, who are followed up in the ward. Atelectasis should

be kept in mind in the presence of clinically pathological respiratory symptoms and signs. Treatments for atelectasis such as chest physiotherapy, nebulized bronchodilator, and mucolytic agents, ventilation support in necessary cases should be initiated early and flexible bronchoscopy should be performed in cases that show no response.

Ethics Committee Approval: The study was approved by the ethics committee of our hospital (Ethics Committee approval number: 0.01/171).

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