International Journal of General Medicine Dovepress

Open Access Full Text Article ORIGINAL RESEARCH

Comparison of Clinical Characteristics and Prognosis Among Spontaneous Pneumothorax Patients of Different Ages: A Two-Year Follow-Up Study

Ting Wang[1], Yang Bai[2]

[1]Department of Respiratory Medicine, Xi'an People's Hospital (Xi'an No.4 hospital), Xi'an, 710004, People's Republic of China; [2]Department of Medical Ultrasonics, Xi'an People's Hospital (Xi'an No.4 hospital), Xi'an, 710004, People's Republic of China

Correspondence: Yang Bai, Department of Medical Ultrasonics, Xi'an People's Hospital (Xi'an No.4 hospital), Xi'an, 710004, People's Republic of China, Tel/Fax +86-18220874065, Email 49876597@qq.com

Purpose: Spontaneous pneumothorax (SP), which is usually characterized by sudden chest pain and shortness of breath, can occur at any age. In this study, patients with SP across various age groups were enrolled, and their clinical features and prognoses were compared.

Patients and Methods: The patients were divided into three groups: neonates (n=52), adolescents/adults (n=76), and elderly (n=70). All patients were followed up for two years. The patients' clinical characteristics, treatments, laboratory indicators on admission, and symptoms over two years were collected and compared. Additionally, as most patients in the elderly group had chronic obstructive pulmonary disease (COPD), data about patients' lung function tests and medication were also analyzed.

Results: Compared with adolescents/adults (6.45±0.24 days), patients with SP in the neonate and elderly groups had more comorbidities, resulting in a longer hospital stay (13.85±0.34 days in neonates and 9.50±0.36 days in the elderly). The main comorbidities in the latter two groups were neonatal asphyxia (17/52) and COPD (48/70), respectively. During the two-year follow-up period, elderly patients with SP had more long-term respiratory symptoms, including coughing, expectoration, and dyspnea, than those in the other two groups. Analysis of the main subgroup (48 COPD cases) in the elderly group revealed that, in the two years after the occurrence of pneumothorax, acute exacerbation times increased; group E cases/(A+B) cases were 4/44, 4/44, 5/43, and 7/41 every 6 months respectively. Additionally, lung function indexes (FEV1, FVC, $MEF_{25,50,75}$) decreased.

Conclusion: Compared to adolescents and adults, newborn and elderly patients with SP are more prone to comorbid lung diseases and longer hospitalization times. The prognosis of neonates is significantly better than the other groups. Increased frequency of acute exacerbations and a deteriorating trend in pulmonary function were observed in patients with COPD after discharge.

Keywords: spontaneous pneumothorax, neonate, adolescent, elderly, prognosis

Introduction

The pleural cavity, formed by the transition between the visceral and parietal pleura at the root of the lung, is a potential space.[1] A small amount of serous fluid, but no gas, can be found inside the pleural cavity, which is important for friction reduction, negative pressure maintenance, lung expansion, and blood and lymph reflux.[2] Pneumothorax occurs when air is present in the pleural space and is usually associated with visceral or parietal membrane damage.[3] Based on etiology, pneumothorax is classified as spontaneous (primary vs secondary) or acquired (iatrogenic vs traumatic), with the former accounting for a greater proportion of cases. Based on pathophysiology, it is divided into closed/simple, open, and tension/high-pressure pneumothorax.[4] The main symptoms of spontaneous pneumothorax (SP) are sudden chest pain and shortness of breath, often accompanied by other discomfort such as cough.[5] As a life-threatening emergency, patients with SP, especially those with large areas of lung compression, require prompt recognition and timely treatment,

Received: 6 August 2024
Accepted: 20 October 2024
Published: 6 December 2024

including oxygen inhalation and closed thoracic drainage.[6] In terms of epidemiology, SP occurs at any age, with an incidence ranging from 6 to 66 per 100,000 per year and a one-year recurrence rate of 29%. A bimodal age distribution is observed, with a high frequency in 15- to 30-year-old individuals and in those ≥65 years old.[4] In contrast to younger patients, who generally develop primary SP (PSP) in the absence of underlying pulmonary diseases, elderly patients often develop secondary SP (SSP) related to basic lung disorders, such as chronic obstructive pulmonary disease (COPD), emphysema, interstitial lung diseases, and pulmonary infection.[7] Meanwhile, SP is also common in neonates because of risk factors such as meconium aspiration, lung immaturity, and infections.[8] Population characteristics, disease onset, clinical features, and prognosis vary among different age groups.

Considering that SP can occur at any age and is a common complication of COPD, determining the clinical characteristics and long-term prognoses of different age groups is necessary to improve our understanding of the condition. In this study, patients with SP in various age groups were enrolled and followed up for two years. The patients' clinical characteristics, treatments, laboratory indicators on admission, and symptoms over two years (6, 12, 18, and 24 months) were collected, compared, and summarized. To the best of our knowledge, this study is the first to investigate the characteristics of patients with SP in different age groups with long-term follow-up.

Materials and Methods

Subjects

Patients diagnosed with SP who were admitted to the respiratory, thoracic surgery, and neonatology departments of our hospital between January 2020 and June 2022 were recruited. Patients with acquired pneumothorax caused by invasive medical procedures or trauma were excluded. Data were collected from medical records, including demographic information, imaging, treatment during hospitalization, and laboratory indicators. Patients were divided into three groups based on age: neonates (≤28 days), adolescents/adults (>10 and <65 years), and elderly (≥65 years). Pneumothorax size was calculated as the ratio of the cubed diameters of the collapsed lung and hemithorax on chest radiography, as follows:

$$\text{pneumothorax size}[\%] = 100 \text{ x } \left[1 - \frac{\text{average lung diameter}^3}{\text{average hemithorax diameter}^3}\right]$$

Treatment

Oxygen inhalation is routine therapy for patients with SP. For newborns with severe pneumonia and acute respiratory distress syndrome (ARDS), mechanical ventilation is essential, with continuous positive airway pressure (CPAP) as the most commonly used ventilation mode. Closed thoracic drainage was performed for patients with a lung compression area of >33%. In the adolescent/adult and elderly groups, majority of patients underwent closed thoracic drainage, accounting for 65.79% and 70%, respectively. In addition, some patients with emphysematous bullae complicating SP underwent thoracoscopic bullectomy.

Follow-Up

All patients were followed up for two years after discharge. The main symptoms, such as cough, expectoration, chest pain, palpitations, and dyspnea, were recorded semi-annually. Additionally, since majority in the elderly group had concomitant COPD, detailed statistical analysis of this subgroup was performed. Lung function indices, acute exacerbation frequency, and changes in medications were assessed every six months in the COPD subgroup. All procedures were conducted according to the principles of the Declaration of Helsinki. Informed consent was obtained from the participants or their guardians.

Statistical Analysis

Microsoft Excel (Microsoft; Redmond, WA, USA) and SPSS version 26.0 (IBM; Chicago, IL, USA) were used for data collection and analysis. Count data, such as sex and comorbidities, were displayed as numbers and percentages (%). Chi-square test was used for comparison of variables among the three groups. Continuity-adjusted formula and Fisher's exact

test was adopted for chi-square test if the value of the expected cases in one cell was ≥1 but <5 or <1 in the table Data with normal distribution were expressed as mean ± standard deviation and analyzed using student's *t* test or one-way ANOVA for comparison among groups. For non-normally distributed variables, the Mann–Whitney *U*-test was performed. The length of hospital stay was compared among the three groups using the Kaplan–Meier method. A two-tailed $P<0.05$ was considered statistically significant.

Results

Population Characteristics

Our study recruited 198 patients diagnosed with SP on imaging, including both PSP and SSP. Patients were divided into neonatal (n=52), adolescent/adult (n=76), and elderly (n=70) groups according to age. As seen in Tables 1 and 2, the main symptoms/signs in adolescents/adults and elderly patients were cough (30/76, 62/70), expectoration (11/76, 36/70),

Table 1 Baseline Demographic and Clinical Characteristics of the Three Groups

Characteristics	Neonatus (n=52)	Adolescent/Adult (n=76)	Elderly (n=70)	P value
Gender				>0.05
Male	28 (53.85%)	46 (60.53%)	52 (74.29%)	
Female	24 (46.15%)	30 (39.47%)	18 (25.71%)	
Age (days/years/years)	0.12±0.03	29.34±2.85	72.49±5.98	<0.00*
Smoking status				<0.05*
Never	–	35 (46.05%)	21 (30.00%)	
Ever	–	41 (53.95%)	49 (70.00%)	
Infant type				–
Preterm (<37 GW)	7 (13.46%)	–	–	
Term (≥ 37GW)	45 (86.54%)	–	–	
SP Type				<0.00*
PSP	43(82.69%)	72(94.74%)	18(25.71%)	
SSP	9(17.31%)	4(5.26%)	52(74.29%)	
Pneumothorax position				>0.05
Left	29(55.77%)	39(51.32%)	33(47.14%)	
Right	20(38.46%)	37(48.68%)	37(52.86%)	
Bilateral	3(5.77%)	0(0.00%)	0(0.00%)	
Pneumothorax classification				<0.05*
Closed	52(100.00%)	72(94.74%)	61(87.14%)	
Open	0(0.00%)	4(5.26%)	9(12.86%)	
Lung compression area				<0.00*
≤1/3	35(67.31%)	15(19.74%)	12(17.14%)	
>1/3, ≤2/3	17(32.69%)	44(57.89%)	49(70.00%)	
>2/3	0(0.00%)	17(22.37%)	9(12.86%)	

(*Continued*)

Table 1 (Continued).

Characteristics	Neonatus (n=52)	Adolescent/Adult (n=76)	Elderly (n=70)	P value
Commodity				
COPD	–	2(2.63%)	48(68.57%)	<0.00*
Pulmonary infection	3(5.77%)	2(2.63%)	12(17.14%)	<0.05*
Asthma	–	3(3.95%)	0(0.00%)	>0.05
Lung cancer	–	0(0.00%)	4(5.71%)	0.05
Acute respiratory distress syndrome	14(26.92%)	3(3.95%)	8(11.43%)	<0.01*
Transient tachypnea of the newborn	15(28.85%)	–	–	–
Meconium aspiration syndrome	9(17.31%)	–	–	–
Neonatal asphyxia	17(32.69%)	–	–	–
Coronary heart disease	–	6(7.89%)	21(30.00%)	<0.01*
Hypertension	–	6(7.89%)	14(20.00%)	0.03*
Type 2 diabetes	–	8(10.53%)	11(15.71%)	>0.05
Biochemical index				
BMI	13.03±2.56	22.85±3.78	23.21±4.07	<0.00*
PH	7.36±0.83	7.39±0.46	7.39±0.52	>0.05
PO_2 (mmHg)	81.94±7.74	83.27±6.39	77.68±8.32	<0.00*
PCO_2 (mmHg)	34.37±2.98	33.49±3.14	44.89±4.06	<0.00*
WBC (*10^9/L)	7.38±0.25	8.93±0.46	9.01±1.02	>0.05
HGB (g/L)	130.05±9.14	129.37±10.56	132.43±10.95	>0.05
PLT (/L)	218.48±12.37	205.83±14.38	217.74±12.66	>0.05
ALB (g/L)	39.34±2.65	40.27±3.21	39.48±4.03	>0.05
Creatinine (μmol/L)	80.42±7.26	79.84±7.53	78.27±8.06	>0.05
BUN (mmol/L)	5.28±0.23	5.12±0.71	5.06±0.93	>0.05
Main treatments				
Oxygen inhalation				
Low flow (≤2L/min)	8(15.38%)	11(14.47%)	5(7.14%)	>0.05
Medium/high flow (>2L/min)	12(23.08%)	65(85.52%)	65(92.86%)	<0.00*
Mechanical ventilation	32(61.54%)	0(0.00%)	1(1.43%)	<0.00*
Closed thoracic drainage	0(0.00%)	50(65.79%)	49(70.00%)	<0.00*
Antibiotic	28(53.85%)	32(42.11%)	48(68.57%)	>0.05

Note: *A two-tailed P<0.05 means statistically significance.

Abbreviations: GW, gestational week; SP, Spontaneous pneumothorax; PSP, Primary Spontaneous pneumothorax; SSP, Secondary Spontaneous pneumothorax; COPD, Chronic obstructive pulmonary disease; BMI, Body mass index; WBC, White blood cell; HGB, Hemoglobin; PLT, Platelet; ALB, Albumin; BUN, Blood urine nitrogen; CRP, C-reactive protein.

Table 2 Clinical Symptoms and Prognosis of the Three Groups in Two Years

Clinical symptoms	Infants/Children (n=52)	Adolescent/Adult (n=76)	Elderly (n=70)	P value
On admission				
Cough	0(0.00%)	30(39.47%)	62(88.57%)	<0.00*
Expectoration	0(0.00%)	11(14.47%)	36(51.43%)	<0.00*
Chest pain	–	52(68.42%)	48(68.57%)	>0.05
Hemoptysis	0(0.00%)	2(2.63%)	4(5.71%)	>0.05
Palpitate	–	33(43.42%)	40(57.14%)	>0.05
Respiratory distress/Dyspnoea	50(96.15%)	42(55.26%)	58(82.86%)	<0.00*
Cyanochroia	28(53.85%)	2(2.63%)	4(5.71%)	<0.00*
Death	1(1.92%)	0(0.00%)	1(1.43%)	>0.05
After 6 months				
Cough	0(0.00%)	19(25.00%)	51(73.91%)	<0.00*
Expectoration	0(0.00%)	2(2.63%)	30(43.48%)	<0.00*
Chest pain	–	4(5.26%)	9(13.04%)	<0.00*
Hemoptysis	0(0.00%)	0(0.00%)	0(0.00%)	>0.05
Palpitate	–	6(7.89%)	23(33.33%)	<0.00*
Dyspnoea	0(0.00%)	9(11.84%)	23(33.33%)	<0.00*
Cyanochroia	0(0.00%)	1(1.32%)	5(7.25%)	>0.05
Death	0(0.00%)	0(0.00%)	1(1.45%)	>0.05
Recurrence	0(0.00%)	2(2.63%)	3(4.35%)	>0.05
After 12 months				
Cough	0(0.00%)	15(19.74%)	45(66.18%)	<0.00*
Expectoration	0(0.00%)	3(3.95%)	23(33.82%)	<0.00*
Chest pain	–	1(1.32%)	8(11.76%)	<0.05*
Hemoptysis	0(0.00%)	00(0.00%)	00(0.00%)	>0.05
Palpitate	–	3(3.95%)	11(16.18%)	<0.05*
Dyspnoea	0(0.00%)	6(7.89%)	29(42.65%)	<0.05*
Cyanochroia	0(0.00%)	0(0.00%)	4(5.88%)	<0.05*
Death	0(0.00%)	0(0.00%)	1(1.47%)	>0.05
Recurrence	0(0.00%)	4(5.26%)	6(8.82%)	>0.05
After 18 months				
Cough	0(0.00%)	11(14.47%)	42(62.69%)	<0.00*
Expectoration	0(0.00%)	4(5.26%)	21(31.34%)	<0.00*
Chest pain	–	0(0.00%)	6(8.96%)	<0.00*

(*Continued*)

Table 2 (Continued).

Clinical symptoms	Infants/Children (n=52)	Adolescent/Adult (n=76)	Elderly (n=70)	P value
Hemoptysis	0(0.00%)	0(0.00%)	0(0.00%)	>0.05
Palpitate	–	4(5.26%)	9(13.43%)	>0.05
Dyspnoea	0(0.00%)	3(3.95%)	22(32.84%)	<0.00*
Cyanochroia	0(0.00%)	0(0.00%)	4(5.97%)	<0.05*
Death	0(0.00%)	0(0.00%)	0(0.00%)	>0.05
Recurrence	0(0.00%)	3(3.95%)	4(5.97%)	>0.05
After 24 months				
Cough	0(0.00%)	9(11.84%)	42(62.69%)	<0.00*
Expectoration	0(0.00%)	4(5.26%)	20(29.85%)	<0.00*
Chest pain	–	0(0.00%)	3(4.48%)	>0.05
Hemoptysis	0(0.00%)	0(0.00%)	0(0.00%)	>0.05
Palpitate	–	4(5.26%)	4(5.97%)	>0.05
Dyspnoea	0(0.00%)	3(3.95%)	15(22.39%)	<0.00*
Cyanochroia	0(0.00%)	0(0.00%)	3(4.48%)	>0.05
Death	0(0.00%)	0(0.00%)	2(2.99%)	>0.05
Recurrence	0(0.00%)	0(0.00%)	2(2.99%)	>0.05

Note: *A two-tailed P<0.05 means statistically significance.

chest pain (52/76, 48/70), palpitations (33/76, 40/70), dyspnea (42/76, 58/70), and cyanochroia (2/76, 4/70). Meanwhile, neonates with pneumothorax mainly showed signs of respiratory distress (50/52) and cyanochroia (28/52). In contrast to patients with SP in the adolescent/adult group, SP patients in the neonatal and elderly groups had high incidence rates of basic lung disorders or other underlying diseases (Table 1). Neonatal asphyxia (17/52), acute respiratory distress syndrome (14/52), transient tachypnea (15/52), and meconium aspiration syndrome (9/52) were particularly common. In the elderly group, patients with SP were more likely to have COPD (48/70), pneumonia (12/70), coronary heart disease (21/70), and hypertension (14/70) (all $P<0.05$). Compared to the other groups, patients in the elderly group tended to have a higher proportion of SSP (74.29%), which was closely related to pulmonary diseases such as COPD. SP patients in the neonatal and elderly groups had longer hospital stays than those in the adolescent/adult group (13.85±0.34 days vs 9.50±0.36 days vs 6.45±0.24 days) (Figure 1). Compared to the neonatal group, SP patients in the adolescent/adult and elderly groups tended to have higher rates of severe lung compression, requiring closed thoracic drainage ($P<0.05$). In addition, deteriorating blood gas analysis indicators, such as low oxygen and high carbon dioxide partial pressures, were observed in elderly patients ($P<0.05$).

Follow-Up (Every 6 Months)

Table 2 provides information on sustained symptoms in the three groups during follow-up. We compared the common clinical manifestations among the three groups every six months for two years. The data showed that positive symptoms were most frequent in elderly SP patients than in the other age groups. Specifically, at 6-month follow-up, elderly patients had high rates of cough (51/69), expectoration (30/69), chest pain (9/69), palpitations (23/69), dyspnea (23/69), and cyanochroia (5/69) (all $P<0.05$). On 12-month follow-up, although the proportion of patients experiencing discomfort declined in the elderly group (cough: 45/68, expectoration: 23/68, chest pain: 8/68, palpitations: 11/68, dyspnea: 29/68,

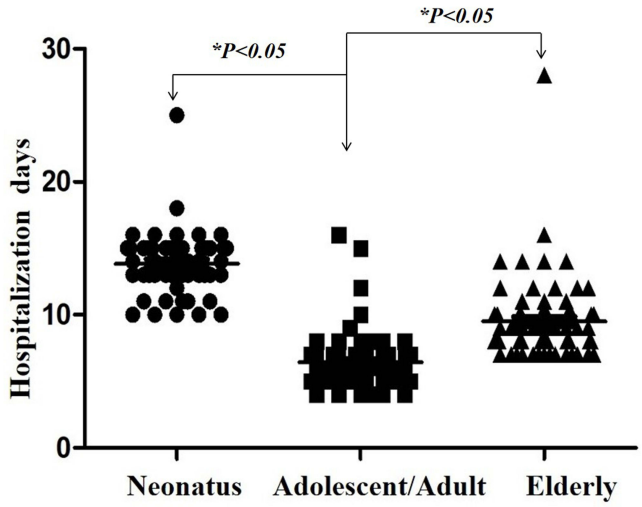

Figure 1 Comparison of the hospitalization days among three groups. *A two-tailed P<0.05 means statistically significance.

cyanochroia: 4/68), it was still higher than that in neonates or adolescents/adults. On follow-up after 18 to 24 months, this difference was still present (P<0.05). In addition, four patients died of pulmonary diseases in the elderly group during the follow-up period.

Analysis of COPD Patients with SP

Since majority of elderly SP patients also had COPD, further analysis of the clinical features of this patient subgroup was performed. As seen in Table 3, after recovery from pneumothorax, the patients' lung function indicators (FEV1, FVC, $MEF_{25,50,75}$) gradually deteriorated during the two-year follow-up period (P<0.05). Although no statistically significant difference was observed, an elevated trend could still be seen in terms of the frequency of acute exacerbation and number

Table 3 Lung Function Indexes and Clinical Characteristics of the Patients with COPD in Two Years

COPD Patients (48 cases)	Before Admission	After 6 Months	After 12 Months	After 18 Months	P Value
FEV_1(L)	2.16±0.63	1.92±0.29	1.75±0.71	1.34±0.48	<0.05*
FVC(L)	3.25±1.02	3.00±0.78	2.87±0.81	2.69±0.58	<0.05*
FEV_1/FVC(%)	66.16±9.83	63.16±8.74	61.98±10.16	54.76±6.53	<0.05*
MEF_{25}	1.01±0.42	0.84±0.16	0.79 ±0.21	0.63±0.33	<0.5*
MEF_{50}	3.38±1.06	2.96±0.53	2.61±0.46	2.44±1.02	<0.05*
MEF_{75}	6.08±1.82	5.21±1.28	4.86±1.37	4.15±1.64	<0.05*
Treatments					
LAMA	6	4	4	2	>0.05
ICS+LABA	20	23	25	26	>0.05
ICS+LABA+LAMA	5	7	8	10	>0.05
Others	23	20	17	16	>0.05
CAT score	20.38±0.14	21.25±0.15	22.31±0.21	23.96±0.22	<0.00*
mMRC grade	1.81±0.08	1.96±0.08	2.10±0.09	2.35±0.09	<0.00*

(*Continued*)

Table 3 (Continued).

COPD Patients (48 cases)	Before Admission	After 6 Months	After 12 Months	After 18 Months	P Value
Group					
A	12	9	6	2	>0.05
B	32	35	37	39	>0.05
E	4	4	5	7	>0.05

Note: *A two-tailed P<0.05 means statistically significance.
Abbreviations: COPD, Chronic obstructive pulmonary disease; FEV_1, Forced expiratory volume in the first second; FVC, Forced vital capacity; MEF, Maximal expiratory flow; LAMA, Long acting anticholinergic antagonists; ICS, Inhaled corticosteroids; LABA, Long lasting effect β_2 receptor agonists.

of patients with COPD in group E; evaluated every six months for two years, the group E cases/(A+B) cases were 4/44, 4/44, 5/43, and 7/41.

Discussion

In this study, we found that neonates and elderly SP patients tended to have more comorbidities and longer hospital stays than adolescents/adults with SP. Further comparisons among the groups indicated that the long-term prognosis was worst in the elderly group. From these data, clinicians can develop a deeper interpretation of the clinical features and long-term prognosis of SP in patients of different ages.

SP may have an insidious or acute onset, results in respiratory difficulty, and may be life-threatening. Typically, SP has a peak incidence in two age categories: PSP is more frequently seen in those between 15 to 34 years old, while SSP is inclined to occur in the elderly (≥65 years old).[9,10] Based on our study, SSP comprised a high percentage of SP in elderly patients (74.29%), while accounting for only 17.31% and 5.26% of SPs in the neonatal and adolescent/adult groups, respectively. Moreover, the majority of newborn patients with SP in our study had comorbidities, which were similar to those listed in the study by Andersson et al, namely asphyxia (28/75), respiratory distress syndrome (20/75), transient tachypnea of the newborn (18/75), and meconium aspiration syndrome (14/75).[11] In studies by Halibullah et al and Joshi et al,[12,13] respiratory distress syndrome, which accounted for 39% and 35.5%, respectively, was the most common underlying lung disease in neonates with SP, followed by transient tachypnea of the newborn (8%, 14.2%) and meconium aspiration syndrome (6%, 11.3%).

Clinical manifestations often depend on pneumothorax size.[14] Compared to newborns, a higher proportion of adolescent/adult and elderly patients in our study had a pneumothorax size >33% and developed disease progression during hospitalization. Common symptoms/signs were cough, expectoration, chest pain, hemoptysis, palpitations, dyspnea, and cyanochroia; the frequencies of symptoms were consistent with those summarized in a previous review (dyspnea: 45–93%, chest pain: 17–92%, cough: 20–43%, and unilateral diminished breath sounds: 73–81%).[15–17] As for neonates, patients with SP have been previously reported to present with tachypnea, cyanosis, grunting and retractions, bradycardia, decreased breath sounds, nasal flaring, or increased respiratory rate.[18,19] In our study, neonates with SP mainly presented with respiratory distress/dyspnea or cyanochroia, reminding pediatricians to carefully observe newborn signs to avoid misdiagnosis. Regarding prognosis, long-term follow-up studies revealed that PSP recurrence rate ranged from 16–52%, often within one year, while SSP showed a higher recurrence rate of 40–56%, usually within 6 months.[20] The one-year recurrence rate of PSP in our study was 6/76 (7.89%) in the adolescent/adult group, which was slightly lower than that reported in other studies from Taiwan, China,[21] and Thailand.[22] Similarly, the prognosis of patients with SSP was better in our study, with a one-year relapse rate of 9/69 (13.04%), which may be explained by the progress in treatments for underlying disorders such as COPD.[22,23] In addition, neonates with SP had a satisfactory prognosis with a low mortality rate of 1/52, which was lower than that in the study by Jovandaric et al,[24] owing to differences in patient characteristics, as majority of newborns in our study were term infants. In addition, our study demonstrated an association between SSP and decreased lung function, as well as increased frequency of acute exacerbations in SP patients with COPD, which had not been evaluated previously. This could be related to considerable lung compression

accompanying a pneumothorax, which often requires closed thoracic drainage or thoracoscopic repair. Additionally, postoperative lung adhesions may have adverse effects on lung function.[25]

Conclusion

Compared to adolescent/adult patients, newborn and elderly patients with SP have more comorbid lung conditions and longer hospital stays. The prognosis of neonates is significantly better than that of elderly patients. For COPD patients who develop SP, increased frequency of acute exacerbations and deteriorating pulmonary function were observed on follow-up.

Abbreviations

SP, Spontaneous pneumothorax; PSP, Primary spontaneous pneumothorax; SSP, Secondary spontaneous pneumothorax; COPD, Chronic obstructive pulmonary disease; ARDS, Acute respiratory distress syndrome; CPAP, Continuous positive airway pressure; FEV_1, Forced expiratory volume in the first second; FVC, Forced vital capacity; MEF, Maximal expiratory flow.

Data Sharing Statement

The datasets used and analyzed in the current study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

The protocol was approved by the Ethics Committee of Xi'an People's Hospital (Xi'an No.4 hospital) and informed consent was obtained from the patients or their guardians. All procedures involving human participants were performed in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Consent for Publication

Written informed consent was obtained from all patients for the publication of any potentially identifying images and clinical details of this study.

Funding

There is no funding to report.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Yalcin NG, Choong CK, Eizenberg N. Anatomy and pathophysiology of the pleura and pleural space. *Thorac Surg Clin*. 2013;23(1):1–10,v. doi:10.1016/j.thorsurg.2012.10.008
2. Jalota Sahota R, Sayad E. *Tension Pneumothorax*. StatPearls. edn ed. Treasure Island (FL): StatPearls Publishing Copyright ©; 2024.StatPearls Publishing LLC.
3. DeMaio A, Semaan R. Management of Pneumothorax. *Clin Chest Med*. 2021;42(4):729–738. doi:10.1016/j.ccm.2021.08.008
4. Huan NC, Sidhu C, Thomas R. Pneumothorax: classification and Etiology. *Clin Chest Med*. 2021;42(4):711–727. doi:10.1016/j.ccm.2021.08.007
5. Zhang J, Xu K, Chen X, Qi B, Hou K, Yu J. Immediate pneumothorax after neurosurgical procedures. *J Int Med Res*. 2020;48 (12):300060520976496. doi:10.1177/0300060520976496
6. Th'ng F, Rao KA, Huang PY. Case series: acupuncture-related pneumothorax. *Int J Emerg Med*. 2022;15(1):48. doi:10.1186/s12245-022-00455-z
7. Sloots JM, Duiverman ML. Pneumothorax in patients with COPD and emphysema receiving home chronic non-invasive ventilation: is it the emphysema phenotype or ventilator setting? *BMJ Case Rep*. 2023;16(1):e253186. doi:10.1136/bcr-2022-253186
8. Matsushita FY, Krebs VLJ, Carvalho WB. Association between ventilatory settings and pneumothorax in extremely preterm neonates. *Clinics*. 2021;76:e2242. doi:10.6061/clinics/2021/e2242
9. Bairwa M, Sharma A, Luniwal M. Secondary spontaneous pneumothorax in patients with silicosis. *J Assoc Physicians India*. 2023;71(10):64–66. doi:10.59556/japi.71.0348
10. Onuki T, Ueda S, Yamaoka M, et al. Primary and secondary spontaneous pneumothorax: prevalence, clinical features, and in-hospital mortality. *Can Respir J*. 2017;2017:6014967. doi:10.1155/2017/6014967

11. Andersson J, Magnuson A, Ohlin A. Neonatal pneumothorax: symptoms, signs and timing of onset in the post-surfactant era. *J Matern Fetal Neonatal Med*. 2022;35(25):5438–5442. doi:10.1080/14767058.2021.1882981
12. Halibullah I, Hammond F, Hodgson K, Duffy N, Stewart M, Sett A. Management of pneumothorax in neonatal retrieval: a retrospective cohort study. *Arch Dis Child Fetal Neonatal Ed*. 2023;108(2):182–187. doi:10.1136/archdischild-2022-324352
13. Joshi A, Kumar M, Rebekah G, Santhanam S. Etiology, clinical profile and outcome of neonatal pneumothorax in tertiary care center in South India: 13 years experience. *J Matern Fetal Neonatal Med*. 2022;35(3):520–524. doi:10.1080/14767058.2020.1727880
14. Çıtak N, Özdemir S. Which pneumothorax volume/size measurement method can best predict surgical indication in primary spontaneous pneumothorax patients? A comparison of six different methods. *Gen Thorac Cardiovasc Surg*. 2022;70(10):871–879. doi:10.1007/s11748-022-01800-y
15. Gilday C, Odunayo A, Hespel AM. Spontaneous pneumothorax: pathophysiology, clinical presentation and diagnosis. *Top Companion Anim Med*. 2021;45:100563. doi:10.1016/j.tcam.2021.100563
16. Yazkan R, Han S. Pathophysiology, clinical evaluation and treatment options of spontaneous pneumothorax. *Tuberk Toraks*. 2010;58(3):334–343.
17. Ghisalberti M, Guerrera F, De VA, et al. Age and clinical presentation for primary spontaneous pneumothorax. *Heart Lung Circ*. 2020;29(11):1648–1655. doi:10.1016/j.hlc.2020.05.107
18. Jhaveri V, Vali P, Giusto E, Singh Y, Lakshminrusimha S. Pneumothorax in a term newborn. *J Perinatol*. 2024;44(4):465–471. doi:10.1038/s41372-024-01899-2
19. Adekoya AO, Adekoya AO, Amosu LO, Olatunji AA, Olusola-Bello MA, Ashaolu OO. Primary spontaneous pneumothorax in a term neonate. *Afr Health Sci*. 2022;22(4):178–181. doi:10.4314/ahs.v22i4.21
20. Riveiro-Blanco V, Pou-álvarez C, Ferreiro L, et al. Recurrence of primary spontaneous pneumothorax: associated factors. *Pulmonology*. 2022;28(4):276–283. doi:10.1016/j.pulmoe.2020.06.003
21. Hung WT, Chen HM, Wu CH, Hsu WM, Lin JW, Chen JS. Recurrence rate and risk factors for recurrence after thoracoscopic surgery for primary spontaneous pneumothorax: a nationwide population-based study. *J Formos Med Assoc*. 2021;120(10):1890–1896. doi:10.1016/j.jfma.2020.12.011
22. Saiphoklang N, Kanitsap A. Prevalence, clinical manifestations and mortality rate in patients with spontaneous pneumothorax in Thammasat University Hospital. *J Med Assoc Thai*. 2013;96(10):1290–1297.
23. Brusselle G, Himpe U, Fievez P, et al. Evolving to a single inhaler extrafine LABA/LAMA/ICS - inhalation technique and adherence at the heart of COPD patient care (TRIVOLVE). *Respir Med*. 2023;218:107368. doi:10.1016/j.rmed.2023.107368
24. Jovandaric MZ, Milenkovic SJ, Dotlic J, et al. Neonatal pneumothorax outcome in preterm and term newborns. *Medicina*. 2022;58(7):965.
25. Nakajima J, Takamoto S, Murakawa T, Fukami T, Yoshida Y, Kusakabe M. Outcomes of thoracoscopic management of secondary pneumothorax in patients with COPD and interstitial pulmonary fibrosis. *Surg Endosc*. 2009;23(7):1536–1540. doi:10.1007/s00464-009-0438-y