

Thoracoscopy in the treatment of spontaneous pneumothorax in children

Andrzej Grabowski, Wojciech Korlacki, Michał Pasierbek, Filip Achtelek

Clinic and Department of Pediatric Malformation Surgery and Traumatology, Medical University of Silesia, Zabrze, Poland

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Abstract

Background: Spontaneous pneumothorax occurring in children is routinely treated in a conservative manner. An important clinical problem is to find solutions for patients with persistent or recurrent pneumothorax. The surgery previously executed with classic thoracotomy is now performed with thoracoscopic access.

The aim of this study was to analyze the effectiveness of thoracoscopic interventions in children with spontaneous pneumothorax.

Material and methods: The work was based on a retrospective evaluation of the records of 46 patients operated on for spontaneous pneumothorax in the years 1997–2012. The assessment takes into account patient demographics, length of hospital stay, and the type of surgical procedure. The immediate and long-term postoperative period was followed, with particular attention paid to pathology recurrence.

Results: In the years 1996–2011, 46 patients (11 girls and 35 boys) were treated surgically for spontaneous pneumothorax. The average age was 15.48 years (range: 11–18 years), mean weight – 58.7 kg (range 33–76 kg). 52 thoracoscopic procedures were performed in 46 patients. In 5 patients, interventions for recurrent pneumothorax on the opposite side were necessary. Time of hospital stay after surgery ranged from 3 to 33 days (average of 7.35). There were no deaths. Complications during hospitalization occurred in 8 patients (17.4%).

Conclusions: Minimally invasive thoracoscopic intervention in the case of spontaneous pneumothorax in children is an effective and safe method of treatment. It is burdened with negligible risk of recurrence, which reduces the exposure of the child to repeated thoracocenteses or drainage of the pleural cavity.

Key words: spontaneous pneumothorax, thoracoscopy, children.

Streszczenie

Wstęp: Obowiązującym standardem postępowania w przypadku odmy samoistnej występującej u dzieci jest leczenie zachowawcze. Istotny problem kliniczny stanowią pacjenci, u których dochodzi do dopełniania się odmy, oraz pacjenci z nawrotowymi zmianami. Zabieg chirurgiczny uprzednio wykonywany drogą torakotomii klasycznej obecnie przeprowadza się z dostępu torakoskopowego.

Cel pracy: Analiza skuteczności zastosowania torakoskopowych interwencji operacyjnych u dzieci z samoistną odmą opłucnową.

Materiał i metody: Praca została oparta na retrospektywnej ocenie dokumentacji 46 pacjentów operowanych z powodu odmy samoistnej w latach 1997–2012. W ocenie wzięto pod uwagę dane demograficzne pacjentów, długość pobytu szpitalnego, rodzaj procedury operacyjnej oraz oceniono bezpośrednio i odległy przebieg pooperacyjny, ze szczególnym zwróceniem uwagi na nawrót patologii.

Wyniki: W latach 1996–2011 leczono operacyjnie z powodu odmy samoistnej 46 pacjentów (11 dziewcząt i 35 chłopców). Średnia wieku wyniosła 15,48 roku (zakres: 11–18 lat), średnia masa ciała 58,7 kg (zakres 33–76 kg). Z powodu odmy samoistnej wykonano łącznie 52 zabiegi torakoskopowe u 46 pacjentów. U 5 pacjentów konieczna była interwencja z powodu nawrotu odmy opłucnowej po stronie przeciwległej. Czas hospitalizacji po zabiegu obejmował 3–33 dni, średnio 7,35 dnia. Nie było zgonów. Powikłania w czasie hospitalizacji wystąpiły u 8 pacjentów (17,4%).

Wnioski: Małoinwazyjne torakoskopowe interwencje w przypadku samoistnej odmy opłucnowej u dzieci są skuteczną i bezpieczną metodą leczenia. Dają znikome ryzyko nawrotu choroby, co zmniejsza narażenie dziecka na kolejne powtarzane punkcje lub drenaże jamy opłucnej.

Słowa kluczowe: odma samoistna, torakoskopia, dzieci.

Address for correspondence: Andrzej Grabowski, Clinic and Department of Pediatric Malformation Surgery and Traumatology, 3 maja 13-15, 41-800 Zabrze, Poland, e-mail: agrabowski@szpital.zabrze.pl

Introduction

The current standard procedure for treating spontaneous pneumothorax in children consists in conservative treatment, selected on the basis of the intensity of changes and symptoms. The available options include passive oxygen therapy and rest, thoracocentesis with a one-time evacuation of air from the pleural cavity, and pleural drainage (passive or using negative pressure) [1].

A significant clinical problem is posed by patients in whom pneumothorax persists despite using all available conservative methods and by patients with recurrent changes within the same or the opposite side of the chest. Surgical procedures aimed at closing the leak site used to be performed with the use of classic thoracotomy; currently, due to the availability of minimally invasive techniques, they are increasingly often performed via thoracoscopic access.

However, the literature review conducted as part of this study revealed only a handful of publications concerning thoracoscopic repair in patients with spontaneous pneumothorax that would pertain only to the pediatric population.

The aim of this study was to analyze the efficacy of thoracoscopic surgical interventions in children with spontaneous pneumothorax.

Material and methods

The present work is based on a retrospective evaluation of the documentation of 46 patients operated on due to spontaneous pneumothorax between the years 1997 and 2012. Patients with pneumothorax that was secondary to concomitant lung pathologies, traumatic pneumothorax, or pneumothorax that accompanied mechanical ventilation were excluded from the study. Since our center functions as a referral center for thoracic surgery cases in the region, some of the patients were referred from other hospitals – usually after the failure of initial conservative or surgical treatment. The remaining patients were admitted as part of the center's emergency duty and were qualified for surgical treatment after initial conservative therapy.

The assessment took into consideration the demographic data of patients, the length of hospital stay, and the type of surgical procedure; the immediate and long-term postoperative course was also assessed, with particular focus on pathology recurrence.

Chest X-rays were performed in all patients; in 16 patients, high resolution computed tomography was performed as well.

Patients with their first episode of pneumothorax were qualified for surgical treatment due to persistent leakage of air into the pleural cavity, defined as a lack of improvement on the check X-ray on the first to fourth day of treatment or persisting signs of leakage in the drainage [2]. This scheme pertained only to the patients treated at the center from the beginning; therefore, the time of conservative treatment before the introduction of the surgical procedure was not included in the evaluation. For the same reason, the patients treated at the center with conservative therapy only were not included in the study. Patients

with pneumothorax recurring on the same side or occurring on the opposite side, as well as patients with pleural hematomas were qualified for surgical treatment without an attempt to treat them conservatively [2].

Procedural technique

Each procedure was performed with the patient lying on the side opposite to the one affected with pneumothorax, remaining under general anesthesia, and intubated with a single-lumen tracheal tube. The optical trocar was usually introduced through the 4th intercostal space, in the midaxillary line. The first instrumental trocar was introduced in the anterior axillary line, through the same intercostal space or one rib higher. The site where the second instrumental trocar was to be introduced was selected under optical control; usually it was located in the 3rd intercostal space in the posterior axillary line. Sufficient operational space was achieved by producing positive pressure in the pleural cavity within the range of 4-6 cm H₂O by carbon dioxide insufflation; therefore, single-bronchus intubation was not necessary.

If the presence of emphysematous bullae or scars after the rupture of such bullae was observed, a resection of the apex of the lung was performed with a linear stapler (Endo GIA) or – if the base of the changed tissue was narrow – by introducing a self-tightening loop and excising the parenchyma above using a LigaSure coagulation device or an ultrasonic knife. Subsequently, electroscarification of the pleura was performed in the apex of the pleural cavity toward the level of the 2nd-3rd intercostal space by applying an active electrode in “spray” mode to the chest wall. If no bullous changes were observed in the lung parenchyma, only the electroscarification of the apex of the pleural cavity was performed, without lung tissue resection. At the end of the procedure, a pleural drain was inserted into the chest through an instrumental trocar; the end of the drain was placed at the apex of the pleural cavity under optical control. The drain was removed after the radiological confirmation of lung expansion if no air leakage was revealed, usually between the 2nd and 4th postoperative day. After being discharged from the ward, the patients continued to be managed as out-patients until reaching the age of 18.

Results

Between the years 1996 and 2011, 46 patients (11 girls and 35 boys) were treated surgically due to spontaneous pneumothorax. The mean age was 15.48 years (range: 11-18 years), mean body weight – 58.7 kg (range: 33-76 kg). Complaints of chest pain or a stinging sensation in the chest, noted in all patients, were limited to the moment identified by the patients as the onset of the pneumothorax. These ailments subsided quickly; subsequently, most patients ($n = 38$, 82.6%) experienced only a decrease in physical capacity, which they described as “minor”. There were no cases of respiratory failure that would require emergency treatment. In 5 patients (10.8%), symptoms suggesting the occurrence of pneumothorax appeared during increased physical exertion (exercise, physical educa-

tion classes, etc.). In two patients (4.3%), it was a result of a blunt trauma to the chest: one of them was hit with a ball, and the other collided with another player. The small force involved in the traumas and the fact that the clinical progression of the patients was analogical to the remaining patients constituted the reasons for not excluding them from the study group, as the traumas were interpreted as trigger factors revealing previously present pathologies.

Twenty-four patients (52.2%) were admitted directly to our center, while 22 (47.8%) were referred from other hospitals. Among the 22 patients referred from other hospitals, initial attempts at pneumothorax repair or treatment had been undertaken in 18 patients before they were referred to our center. Among the patients who had previously been treated in other hospitals, the time from the occurrence of ailments to being referred to our center ranged from 1 to 23 days (mean: 5.46 days). The duration of conservative treatment among the patients who had been previously hospitalized in our center ranged from 0 (procedure on the day of admission) to 7 days (mean: 2.87 days).

Concomitant disorders were observed in 8 patients (17.4%) (Table I). In congenital cystic lung disease, pneumothorax is considered to be a result of lung pathology; however, as pneumothorax occurrence in adult patients with diagnosed emphysematous changes is qualified as spontaneous pneumothorax, and the origin of pneumothorax can always be related to a certain extent of cystic destruction of lung parenchyma, by analogy, two patients with congenital cystic lung disease that had not previously required surgical treatment were also included in the study group. The remaining concomitant diseases have a common origin with spontaneous pneumothorax, rather than having a causal relationship with it; therefore, they were not treated as exclusion criteria for the study group.

In 18 patients (39.1%), spontaneous pneumothorax episodes had been treated once or multiple times within the period preceding their hospitalization covered by this study. In 13 of them, the pneumothorax was present on the same side, in 5 on the opposite side. In total, this amounted to 29 pneumothorax episodes (ranging from 1 to 7 in a single patient), constituting 29 separate hospitalizations. In the remaining 28 patients (60.9%), the reason for admission was the first occurrence of pneumothorax.

Tab. I. Concomitant disorders in patients with spontaneous pneumothorax

Concomitant disorders	Number
pectus carinatum	1
congenital cystic lung disease	2
marfan's syndrome, heart defect, pectus excavatum	1
scoliosis	1
asthma	1
aortic valve insufficiency	1
disruption of heart function	1
total	8

In total, 52 thoracoscopic procedures were conducted in 46 patients due to spontaneous pneumothorax. In 5 patients, an intervention was required due to pneumothorax recurrence on the side opposite to the initially treated side within the period of: 3 weeks, 4 months, 10 months, 11 months, and 12 months, respectively. In one patient, a bilateral thoracoscopy was performed initially due to bilateral pneumothorax. Thoracoscopic excision of the lung apex was performed in 45 cases; thoracoscopic excision of a segment of the lower lobe was performed in one patient. In 45 cases, the resection was combined with electroscarification of the apex of the pleural cavity, and in one case with chemical pleurodesis. In all patients undergoing pulmonary tissue resection, the presence of emphysematous bullae (whole or ruptured bullae or post-bullous scars) was revealed (Vanderschueren's stages III and IV – Table II) [3]. Such changes were not observed in 6 patients (Vanderschueren's stages I or II) [3]. In the latter cases, only the electroscarification of the apex of the pleural cavity was performed. In two patients, a concomitant hematoma of the pleural cavity was revealed.

Drainage was maintained for a period ranging from 1 to 29 days (mean: 5.5 days). The two longest drainage periods (25 and 29 days) were related to patients with pneumothorax recurrence during the hospitalization.

The length of hospitalization after the procedure ranged from 3 to 33 days (mean: 7.35 days); the total length of hospitalization ranged from 3 to 37 days (mean: 8.85 days). There were no deaths in the study group.

During the hospitalization, complications occurred in 8 patients (17.4%). Four of these patients suffered from pneumothorax recurrence (including one recurrence on the side opposite to the one operated on and one bilateral recurrence). Recurrence on the operated side was treated with drainage, while recurrence on the opposite side was treated by means of thoracoscopic intervention. In one patient, pleural effusion was observed and treated with prolonged drainage. Another patient suffered from respiratory failure in the immediate postoperative period, probably partially due to hypovolemia (the patient had a pleural hematoma and vascular malformations of the lung), which was treated with mechanical ventilation and fluid replacement. In one case, the pleural drain was occluded – the pneumothorax worsened and required drain replacement. In one case, prolonged fever was observed, which did not require any modification of treatment due to the employed antibiotic cover.

Tab. II. Lung parenchymal changes accompanying spontaneous pneumothorax according to Vanderschueren's classification

Stage	Macroscopic changes
I	no apparent changes
II	pulmonary-pleural adhesions
III	bullae < 2 cm
IV	bullae > 2 cm

Pneumothorax recurrence on the operated side was observed in 4 patients (8.7%) after hospital discharge. The time of pneumothorax recurrence ranged from the 7th day to the 12th month after discharge (mean: 2.7 months). In all cases, pleural cavity drainage was conducted. In 3 cases, permanent recovery was achieved. In one case, another recurrence was observed after a period of one month. Thoracoscopy was performed and the line of lung tissue excision (staple fasteners) was covered with tissue glue, resulting in a good long-term effect.

Discussion

Spontaneous pneumothorax, defined as an accumulation of air in the pleural cavity without an unequivocally traumatic cause, is a heterogeneous pathological unit. It may occur at three life stages: in infancy; in pubescent teens and young adults; and in elderly patients suffering from chronic obstructive pulmonary disease [4, 5].

In the decisive majority of pediatric patients, the causes of the disorder are not disease-related; the occurrence of pneumothorax is believed to be caused by a pathological disproportion between the pressure within the pleural cavity and the resistance of lung parenchyma. According to previously published data, this disproportion is enhanced especially by the longitudinal growth of the chest, causing a pressure drop in the area of the lung apex, which, combined with an increase in intrapulmonary pressure, results in lung parenchyma porosity and the formation of emphysematous bullae. These changes form the site through which air leaks into the pleural cavity causing pneumothorax [1, 6].

The pathology is usually observed in patients with leptosomic body type, above-average height, and correspondingly lower body mass, primarily boys [2]. Its higher incidence among smokers has been reported, but this relation is less frequent in the pediatric population [2].

The moment of pneumothorax occurrence is usually well recognized by the patients and is associated with temporary symptoms of decreased physical capacity, which usually do not persist longer than 24 hours [2]. The occurrence of pneumothorax is usually not related to any strain; however, cases have been described in which the occurrence took place during physical exertion, while listening to loud music, or even during thunderstorms [7].

Spontaneous pneumothorax is a nosological entity whose treatment in children has not been unequivocally established. In most cases, it requires surgical treatment (thoracocentesis or drainage). At the same time, the recurrence rate of this pathology (up to 60%) burdens the patient with a risk of numerous hospitalizations, generating strain on both the healthcare system and the patient, and suggesting a lack of efficacy of the employed treatment methods [4]. Typical patient guidelines after an episode of spontaneous pneumothorax, such as limiting the activities that could cause an increase of the pressure gradient within the chest (playing wind instruments, diving, airplane travel), physical exertion in particular (exemption from physical education classes!), significantly reduce the patient's long-term quality

of life [1]. The persistent fear of recurrence, experienced by the patients, is also not to be neglected [8-10].

Surgery has been employed in the treatment of spontaneous pneumothorax since 1956 [4, 11]; however, it was not until the introduction of thoracoscopic access [4, 12] that the use of surgical methods in children gained wider acceptance. Thoracoscopic procedures meet all the requirements of minimally invasive methods, providing similar results with smaller recurrence rates [4, 10]. The increased cost of the procedure (in comparison to conservative treatment) is offset by systemic savings, as demonstrated by the example of countries that conduct such calculations [10]. The fact that conservative treatment with drains requires general anesthesia in many cases (particularly in younger children) should also be stressed at this point.

Patients are qualified for the procedure due to the persistence or recurrence of the pathology, with the assumption that surgical treatment will enable the elimination of the cause of the pneumothorax. This can be achieved by excising the pathologically changed lung fragment containing emphysematous bullae [4, 13]. The traditional method for diagnosing the presence of emphysematous bullae has been computed tomography. However, the fact that the presence of bullae (or their remains) is revealed in the decisive majority of patients (77% in our own material) operated on due to persistent air leakage or pneumothorax recurrence suggests that the number of CT examinations can be reduced, especially since this examination becomes reliable with regard to detecting the presence of emphysematous bullae only after lung expansion. In our view and in accordance with the opinions presented by other authors, patients may be qualified for thoracoscopic treatment based on clinical examinations and X-rays of the chest [14]. Moreover, resecting the emphysematous bullae is not the only surgical treatment option; therefore, there is no reason to condition the qualification for surgery on their presence [1, 4, 13, 15]. Intraoperative thoracoscopic imaging allows for the assessment of the lung pathology and facilitates decision making concerning further treatment (Vanderschueren's classification) [3]. It should be kept in mind that lung apex resection is also conducted if ruptured bullae or post-bullous scars are revealed by the thoracoscopic image; in turn, if no lesions are present in the lung tissue, pleural scarification may be performed on its own.

The safety and efficacy of thoracoscopic resection of emphysematous bullae and pleurodesis by electroscarification are confirmed by numerous literature reports [4, 13]. This is also supported by the recurrence rate in our own material, which was 8.7% (in comparison to 54% in the case of non-surgical treatment) [16].

Whether thoracoscopic procedures should be performed during the first episode, regardless of the persistence of air leakage, remains an open question. The proponents of this approach point to the improvements in the quality of life of patients and to decreased total cost [9, 17]. The opponents underscore that 40% of patients do not experience recurrence, the risk of complications is

greater in the group of patients initially treated thoracoscopically, and there is a lack of clinical data based on large, randomized groups of pediatric patients that would meet the high standards of evidence-based medicine [1, 15, 16]. In our material, the decision to perform a thoracoscopic intervention during the first episode of pneumothorax was made in the case of 28 patients (60.9%). The minimal invasiveness of the method and its efficacy at achieving full recovery with a low risk of recurrence encourage more frequent use of these procedures [10].

Conclusions

In conclusion, minimally invasive thoracoscopic interventions constitute safe and efficacious methods of treating spontaneous pneumothorax. They are associated with minute risk of recurrence, which reduces the exposure of children to further, repeated pleural cavity drainage or punctures.

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