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ORIGINAL ARTICLE

Pulmonary pseudocyst secondary to blunt or penetrating chest trauma: clinical course and diagnostic issues

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Abstract
Purpose Traumatic pulmonary pseudocysts (TPPs) are rare complications of chest trauma. The aim of this retrospective study was to report the clinical presentations, diagnosis, complications and treatment for a series of TPPs at a hospital in Turkey.
Methods The charts of 996 patients who were admitted for thoracic trauma between 1999 and 2012 were retrospectively reviewed. Fifty-two patients had TPPs, and the data collected for these individuals were sex, age, and type of trauma (blunt and/or penetrating). Univariate analysis of categorical data was performed using Pearson's Chi square test. Results for continuous variables were statistically compared using the Mann–Whitney *U* test.
Results The patients were 42 males and 10 females aged 12–72 years (mean age 33.1 years). Forty-one had blunt trauma and 11 had penetrating trauma. There was no significant difference between the proportion of blunt trauma patients who developed TPP (41/761, 5.3 %) and the proportion of penetrating trauma patients who developed TPP (11/235, 4.6 %) ($p > 0.05$). All 42 patients had pulmonary contusion. Only 10 patients (19.2 %) had TPP identified on their chest X-ray, and thoracic computed tomography revealed TPP clearly in all these cases. Forty-two patients (80.7 %) were diagnosed with TPP on day 1 post-trauma. The hospital stays ranged from 2 to 35 days for the patients with blunt-trauma, and from 4 to 15 days for those with penetrating trauma (means 8.8 and 8.0 days, respectively; $p > 0.05$). Only one patient required thoracotomy for a pseudocyst that did not resolve and became progressively enlarged. This TPP was resected at 6 months post-trauma. One patient died on day 9 post-trauma due to multiple organ failure. The other 40 pseudocysts resolved spontaneously within 1–5 months.
Conclusions Traumatic pulmonary pseudocysts are pulmonary lesions that occur after either blunt or penetrating trauma and tend to be overlooked. Most of these lesions are self-limiting, benign lesion.

Keywords Chest trauma · Pulmonary pseudocyst

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Introduction

Trauma can cause many patterns of lung injury, and physicians must be equipped to recognize and treat all of these. Acute cystic lesions of the lung parenchyma are rare complications of chest trauma. These cystic air spaces are known as traumatic pulmonary pseudocysts (TPPs) because they lack an epithelial lining. The clinical symptoms associated with TPP tend to be minor. The radiological findings are conspicuous; however, most of these lesions are detected incidentally, and most during computed tomography

scanning (CT) post-trauma as opposed to on a chest X-ray. Traumatic pulmonary pseudocysts are considered benign, and most of these lesions resolve without specific treatment.

The main significance of TPP is that physicians unfamiliar with these lesions may misdiagnose them as malignant or serious abnormalities unrelated to chest trauma [1]. To avoid unnecessary surgeries, it is important that physicians know the criteria for diagnosing TPP, as well as the clinical course and treatment. This article presents a retrospective review of the TPPs that were diagnosed at our hospital in Turkey between 1999 and 2012. The clinical presentations, diagnosis, complications and management of these unusual lesions are discussed in the contexts of our experience and the literature.

Materials and methods

Nine hundred and ninety-six patients with thoracic trauma (761 blunt trauma and 235 penetrating trauma) were admitted to our thoracic surgery department between January 1999 and December 2012. Retrospective review of these patients' charts revealed 52 cases of TPP detected on chest X-ray and/or CT. Forty-one (78.8 %) of the 52 patients had blunt trauma and 11 (21.1 %) had penetrating trauma. All 52 individuals had been assessed using the abbreviated injury scale (AIS) and the injury severity score (ISS). These data were recorded for the study, in addition to each patient's age, sex, thoracic and extrathoracic injuries accompanying TPP, clinical and radiologic findings, hospital stay, morbidity, treatment and outcome.

All 52 patients had undergone chest X-ray and 42 had undergone thoracic CT. Pseudocysts detected on images were identified as circular, oval or lobulated cavitary lesions circumscribed by a thin wall and parenchymal contusion. Diagnosis of TPP was based on the exclusion of other causes of cavitary lung lesions. The major diagnostic criteria were negative history for pulmonary pseudocyst prior to the trauma, typical radiological presentation, location adjacent to or within an area of contusion, rapidly changing pattern of the lesion (from a few days to weeks), and resolution of the cystic lesion on follow-up imaging after no specific treatment.

Statistical analyses were performed using the Statistical Program for the Social Sciences (SPSS version 13, Inc., Chicago, IL, USA). Univariate analysis was performed for categorical data, with the Pearson's Chi square test used to compare proportions of TPP patients based on type of trauma (blunt versus penetrating), age ($\leq$30 versus $>$30 years), and presence of air-fluid levels (in the blunt versus penetrating trauma subgroups). The Mann–Whitney *U* test or Pearson's or Spearman's correlation analysis was used, as appropriate, to analyze AIS relative to size of TPP, and ISS relative to size of TPP. The Mann–Whitney *U* test was used to compare length of hospital stay in the blunt and penetrating trauma groups. p values less than 0.05 were considered to indicate statistical significance.

Results

The 52 patients with TPP were 42 males (80.7 %) and 10 females (19.2 %) aged 12–72 years (mean age 33.1 years). Twenty-eight patients (53.8 %) were 30 years or younger. There was no significant difference between the proportions of younger ($\leq$30 years, $n = 28$) and older ($>$30 years, $n = 24$) patients with TPP (53.8 vs. 46.1 %, respectively; $p > 0.05$).

The incidence of TPP among all thoracic trauma patients admitted to our department during the study period was 5.2 % (52/996). There was no significant difference between the proportion of blunt trauma patients who developed TPP (41/761, 5.3 %) and the proportion of penetrating trauma patients who developed TPP (11/235, 4.6 %) ($p > 0.05$).

Of the 41 blunt chest traumas, 36 (87.8 %) were caused by motor vehicle accidents and 5 (12.1 %) by falls. Of the 11 penetrating traumas, 7 (63.6 %) were gunshot wounds and 4 (36.3 %) were stab wounds.

Chest pain and dyspnea were the 52 patients' major complaints. Initial laboratory studies revealed leukocytosis in 44 (84.6 %) of the patients; the remaining 8 (15.4 %) had normal leukocyte counts. All 52 patients' initial chest X-rays showed various degrees of pulmonary contusion. Only 10 patients (19.2 %) had TPP identified on their chest X-ray on the day of injury (Figs. 1a, 2a, 3a), and thoracic CT revealed TPP clearly in all these cases (Figs. 1b, 2b, 3b). Forty-two patients (80.7 %) were diagnosed with TPP on day 1 post-trauma.

Ten patients (19.2 %) had multiple TPPs. The mean diameter for all TPPs diagnosed in the 52 patients was 4.9 cm (range 1–15 cm). The lesions were restricted to the left lung in 28 patients (upper lobe 17 patients, lower lobe 11 patients), to the right lung in 20 patients (upper lobe 7 patients, lower lobe 13 patients), and were bilateral in 4 patients (all in lower lobes). All detected TPPs were thin-walled lesions, and the lesion pattern changed rapidly (from a few days to weeks) in all cases (Figs. 1b–d, 3b–c).

Eleven patients (21.1 %) had TPPs containing variable amounts of fluid. Nine (21.9 %) of the blunt trauma patients and two (18.1 %) of the penetrating trauma patients had TPPs with air-fluid levels ($p > 0.05$).

The injuries associated with TPP were large contusion ($n = 37$ patients), rib fracture ($n = 29$), hemopneumothorax ($n = 19$), pneumothorax ($n = 16$), extremity and/or clavicle fractures ($n = 12$), hemothorax ($n = 10$),

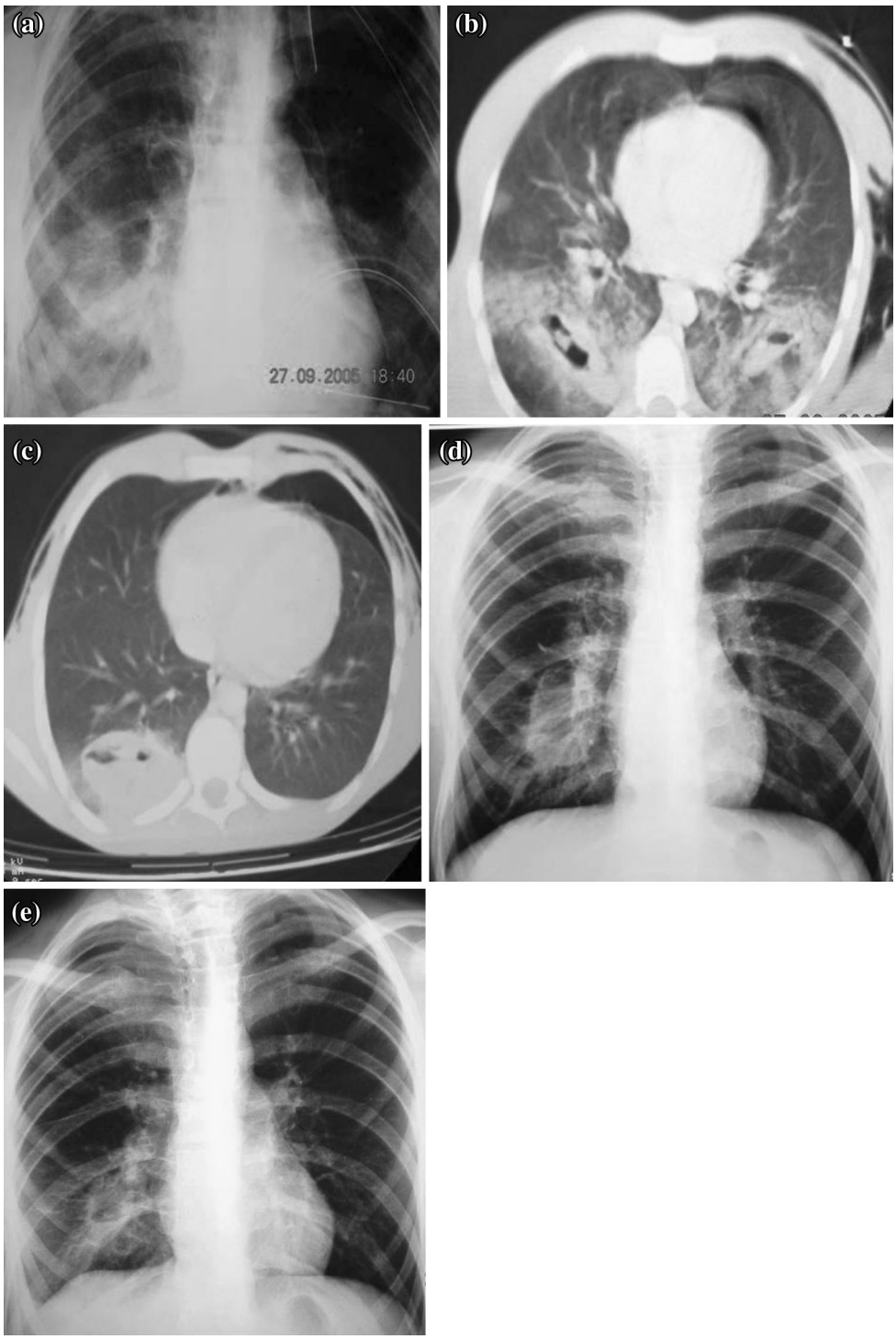

Fig. 1 **a** Eighteen-year-old male patient with blunt thoracic trauma due to traffic accident. He had right-sided hemopneumothorax, left-sided pneumothorax, bilateral pulmonary contusion and pneumomediastinum. Chest X-ray demonstrating extensive pulmonary contusion in the right lower zone and minimal in the left lower zone on day 1. **b** His computed tomography revealed pseudocysts in bilateral lower lobes with adjacent pulmonary contusion areas on day 1. **c** Left-sided pseudocyst resolved while right-sided pseudocyst enlarged and was filled up with fluid in the computed tomography on day 13. **d** Chest X-ray showed that fluid collection in the pseudocyst located in the right lower zone and adjacent pulmonary contusion resolved within the first month. **e** Chest X-ray demonstrated that pseudocyst almost totally resolved on day 60

intraabdominal injury ($n = 7$), vertebral fracture ($n = 5$), subarachnoid hemorrhage ($n = 3$), diaphragmatic rupture ($n = 3$), laceration of the pulmonary artery ($n = 1$) and laceration of the left internal mammary artery ($n = 1$) (Table 1).

The AIS result for chest was 3 for 45 patients (86.5 %) and 4 for 7 patients (13.4 %). The ISS was <16 for 26 patients (50 %) and ≥16 for 26 patients (50 %). Analysis revealed a negative relationship between ISS and size of TPP ($r = -0.071$), and a positive relationship between AIS (chest) and size of TPP ($r = 0.13$); however, neither of these correlations was statistically significant ($p > 0.05$ for both).

All patients received prophylactic antibiotics because of accompanying injuries or because surgery was performed.

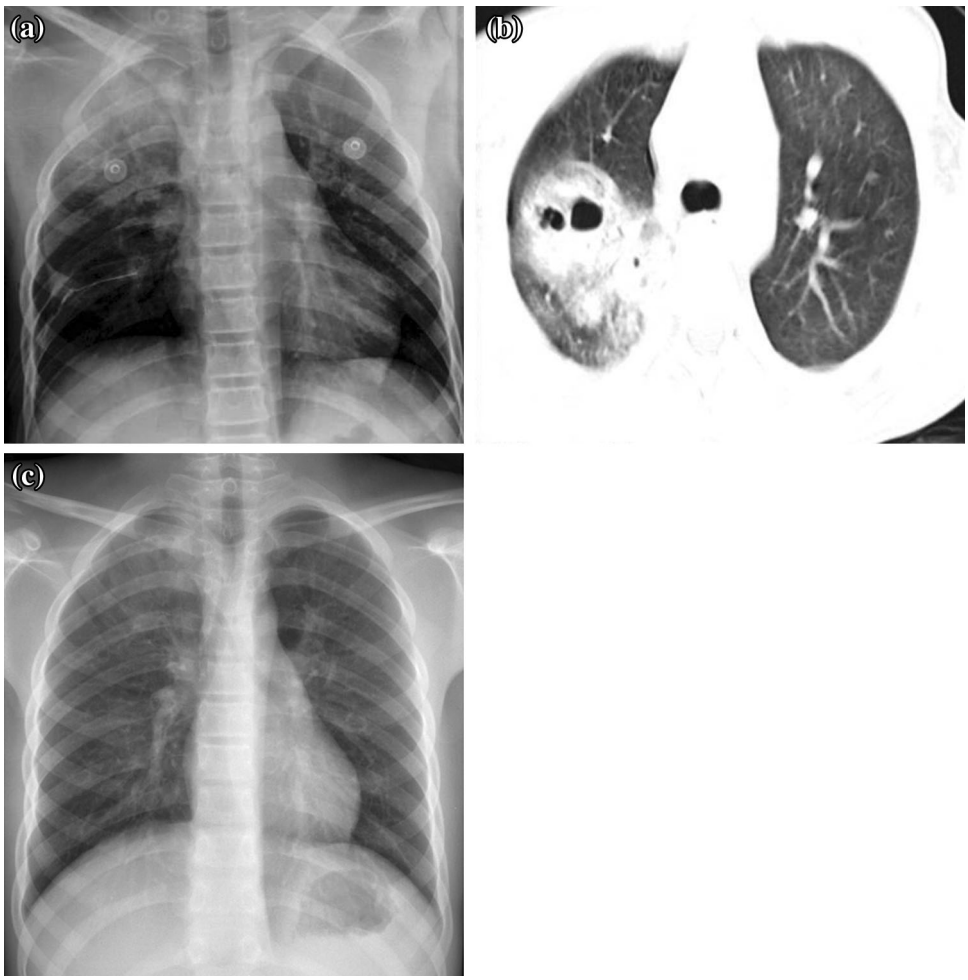

Fig. 2 **a** Twelve-year-old male patient with blunt thoracic trauma due to traffic accident. He had right-sided pneumothorax and pulmonary contusion. His chest X-ray showed extensive pulmonary contusion in right upper zone. **b** Computed tomography showing a large, thin-walled pseudocyst within the area of pulmonary contusion (on the day of trauma). **c** Chest X-ray showed that pulmonary contusion was completely resolved on day 7

Chest tubes were inserted to treat hemothorax and/or pneumothorax in 45 of the patients (86.5 %). Seventeen individuals (32.6 %) underwent surgery to address accompanying injuries: seven thoracotomies, five laparotomies, three rib fixations, one thoracotomy and rib fixation combined, and one orthopedic procedure (Table 2). One of these 17 patients developed a large TPP pseudocyst (10 × 15 cm) and required thoracotomy 6 months after the injury. This was the only case in which a TPP was resected [2]. Histopathological examination of this specimen revealed that that the cyst wall was derived from interstitial connective tissue; it was surrounded by chronic inflammation and an organized hematoma but had no epithelial lining. The other 16 patients required surgery for problems associated with trauma, but none required TPP resection.

The hospital stays ranged from 2 to 35 days for the patients with blunt trauma, and from 4 to 15 days for the patients with penetrating trauma (means 8.8 and 8.0 days, respectively; $p > 0.05$). One patient died on day 9 post-trauma due to multiple organ failure.

Follow-up chest X-rays were obtained at approximately 1, 3 and 6 months after hospital discharge. Eleven (21.1 %) of the 51 patients required follow-up CT to assess post-trauma issues such as residual hemothorax, complications in the pleural space, or persistent TPP. In the 40 patients who had follow-up chest X-ray, the TPPs resolved within 7–105 days (Figs. 1e, 2c, 3d). In 10 of the 11 patients who underwent follow-up CT (91 %), the TPPs resolved spontaneously within 10–150 days. The only surviving patient whose lesion did not resolve was the one patient noted above who required thoracotomy and TPP resection at 6 months [2]. This was the only TPP-related complication in the series (i.e., TPP complication rate 2 %).

Discussion

Chest traumas can cause a range of injuries to the lung parenchyma, including contusion, laceration, hematoma and TPP. The term TPP is used to describe air-filled cystic space that appears in the lung after chest trauma. Most of these lesions develop as a result of blunt chest trauma [2–11], and relatively few reports to date have described TPP associated with penetrating trauma [12, 13]. However, our

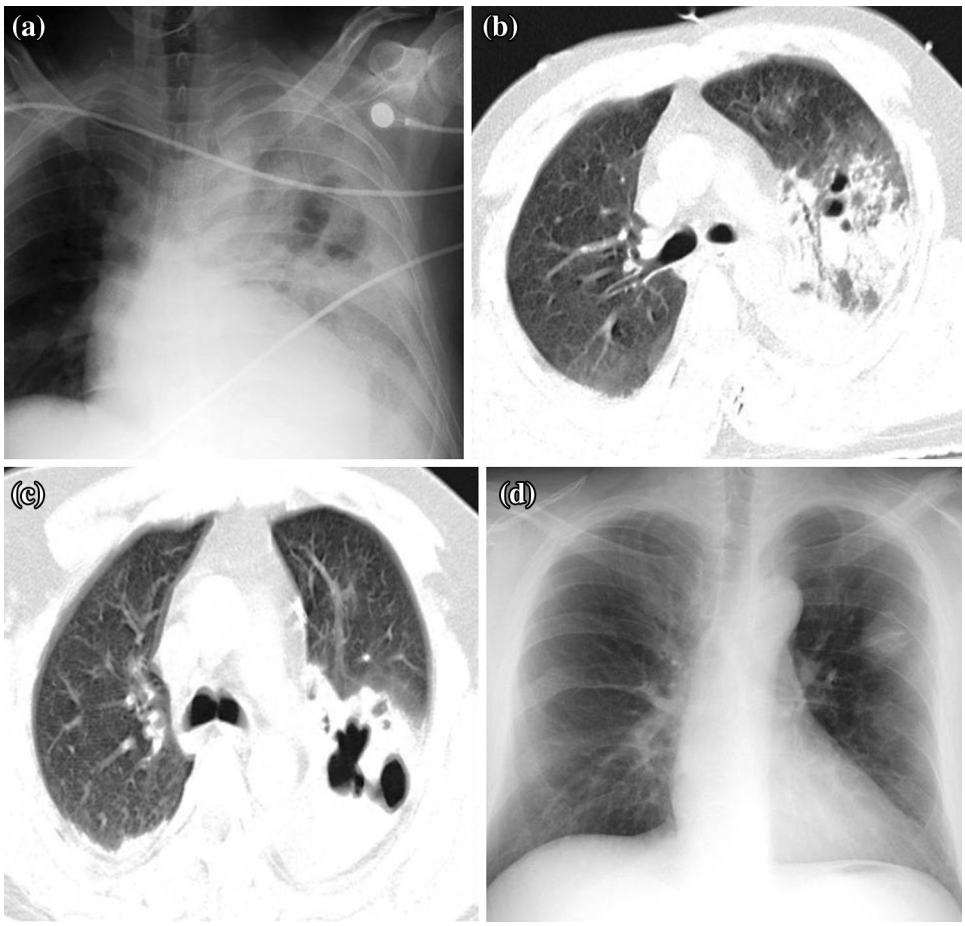

Fig. 3 **a** Thirty-three-year-old male patient with blunt thoracic trauma due to fall. He had left-side hemothorax, and pulmonary contusion, fractures in spine, clavicle and scapula. His chest X-ray shows a lobulated traumatic pulmonary pseudocyst with a thin wall adjacent to an area of pulmonary contusion (on the day of trauma). **b** Computed tomography showing a large, thin-walled pseudocyst within the area of pulmonary contusion (on the day of trauma). **c** Computed tomography showing a large, thin-walled pseudocyst within the area of pulmonary contusion (4 days after trauma). **d** Chest X-rays shows a pulmonary hematoma on the left (3 months after trauma)

findings indicate that these lesions can develop after either blunt or penetrating chest trauma, and we observed no significant difference between the proportions of TPP patients with these trauma types. Another form of injury that leads to pseudocyst is barotrauma. Single or multiple well-demarcated cystic air collections can develop as a complication of mechanical ventilation [14, 15]. This complication has mainly been described in infants.

Most reported TPPs have been in younger patients, particularly males younger than 30 years [4, 6, 9]. Some authors have suggested that the chest wall of younger individuals is more compliant and permits greater transmission of impact to the lung, thus explaining the higher frequency of TPPs in the younger age group [6, 7]. However, we observed no significant difference between the proportions of younger (≤30 years) and older (>30 years) patients with TPP in our study, which confirms that persons of any age can develop these lesions.

The literature describes several mechanisms for development of TPP [3–5]. The consensus is that pulmonary traumatic cysts result from laceration or tearing of lung parenchyma. When a laceration causes only minor vascular damage and does not communicate with the pleural space, air can enter through the laceration and create a cavity. In penetrating lung injury, the laceration involves the visceral pleura, but if the defect seals quickly and forms a semblance of a one-way valve, then a pseudocyst can form. In this situation, the air becomes trapped and the resulting "cyst" has no epithelial lining; interstitial connective tissue forms the lesion's "wall" [2, 16]. These changes occur soon after injury and TPPs usually clear within days.

In accordance with previous reports [7, 8], most of our patients' TPPs (80.8 %) were diagnosed within the first 2 days after chest trauma; however, these lesions are not always apparent on chest X-rays in the first 48 h. Some studies have shown that, for patients with TPP, chest X-ray on the day of injury has a diagnostic yield of 33–50 % [8, 9]. In the early post-trauma period, TPPs may be small and/or may be obscured by opacities of pulmonary contusion on radiographs. In most cases, they are detectable on chest X-ray a few days after trauma because, by this time, lung contusions have resolved to some degree or the TPPs have developed fully. Routine use of CT in cases of chest trauma would likely identify small TPPs that are undetectable on chest X-ray. Melloni et al. reported that 20 % of their 10 TPPs were identified on chest X-ray within the first 24 h

Table 1 Accompanying injuries in the 52 patients with traumatic pulmonary pseudocysts

Injury	No. or patients (% of total)
Large pulmonary contusion	37 (71.2)
Rib fracture	29 (55.8)
Hemopneumothorax	19 (36.5)
Pneumothorax	16 (30.8)
Extremity fracture	12 (23.1)
Hemothorax	10 (19.2)
Intraabdominal injury	7 (13.5)
Vertebral fracture	5 (9.6)
Subarachnoid hemorrhage	3 (5.8)
Diaphragmatic rupture	3 (5.8)
Vascular laceration	2 (3.8)

Table 2 Operations performed in the 17 patients who required surgery

Type of injury	*n* (%)	Operation
Hemothorax and/or pneumothorax and pulmonary laceration	5 (9.6)	Thoracotomy
Hemopneumothorax and diaphragmatic rupture	1 (1.9)	Thoracotomy
Hemopneumothorax and flail chest	1 (1.9)	Thoracotomy, rib fixation
Unresolved pseudocyst	1 (1.9)	Thoracotomy
Diaphragmatic rupture and rib fracture	1 (1.9)	Laparotomy
Splenic rupture and rib fracture	1 (1.9)	Laparotomy
Splenic rupture and hemopneumothorax	1 (1.9)	Laparotomy and chest tube thoracostomy
Splenic rupture and bilateral pneumothorax	1 (1.9)	Laparotomy and chest tube thoracostomy
Liver laceration and hemothorax	1 (1.9)	Laparotomy and chest tube thoracostomy
Flail chest and bilateral hemopneumothorax	1 (1.9)	Rib fixation and chest tube thoracostomy
Flail chest and hemothorax	2 (3.8)	Rib fixation and chest tube thoracostomy
Right upper extremity injury	1 (1.9)	Right upper extremity amputation

post-trauma, and our finding was similar (19.2 %). Melloni et al. suggested that TPPs can be reliably detected on chest X-ray in patients starting from the fifth day after trauma. However, CT scan is considered the definitive method for early diagnosing these lesions [6–8].

Reports published between 1989 and 2003 have indicated that the incidence of TPP among patients with chest trauma is approximately 1 % (range 0.1–2.6 %) [6–8] and among patients with parenchymal injury is 2.5 % (range 2.1–2.9 %) [6, 8]. In two reports published at 2007 and 2012, authors reported 4.7 and 9.8 % incidence of TPP among patients with chest trauma, respectively [3, 4]. At our center, we observed a 5.2 % incidence of TPP among this patient group between 1999 and 2012. These higher rates may be explained by more widespread use of CT as a first-line diagnostic tool in cases of chest trauma.

The diagnosis is based on the imaging findings and history of chest trauma. Chest pain and shortness of breath are the most common complaints of patients with TPP; however, the symptoms and physical and laboratory findings in this patient group tend to be nonspecific and are typically attributed to the trauma rather than this lesion. The typical appearance of TPP on a chest X-ray is a circular, oval or lobulated cavitary lesion immediately adjacent to or within an area of contusion (Figs. 2, 3). The most characteristic feature of TPPs is that they change in size, shape and nature (i.e., the amount of air and fluid content in the cavity) within days. The differential diagnosis for TPP includes bronchial cyst, post-inflammatory pseudocyst, pneumatocele, cavitary tuberculosis, mycotic infection, lung abscess and cancer. A number of multi-systemic conditions, such as Bechterew's disease (ankylosing spondylitis), Sjogren's syndrome, and Wegener's granulomatosis, can also result in development of cystic spaces within the lung [17, 18]. Previous chest radiography, if available, may help to differentiate TPPs from pre-existing cystic lesions.

In our experience, the outcome of TPP can be favorable without specific treatment. Management for these patients is based on symptoms and is limited to symptomatic relief. In most cases, these lesions decrease in size and eventually resolve completely without medical or surgical treatment. Prophylactic antibiotic therapy is not necessary unless other injuries are present or surgical procedures are performed. Chon et al. evaluated 12 cases of TPP and found that time to complete resolution ranged from 9 to 305 days [9]. In 50 of our 51 patients who survived and were followed up, all of the TPPs except one resolved between 7 and 150 days after trauma.

Most cases do resolve without incident, but the prognosis for patients with TPP can be negatively affected by comorbidity associated with the initial trauma, or by any complications that occur. Complications such as infection and abscess formation [19–21], significant hemoptysis [7, 22], and disseminated intravascular coagulation [23] are all rare and should be treated appropriately. Previous researches have indicated that the complications of TPP developed between 1 to 9 days (mostly within 5 days) after trauma [7, 19–23]. Although we did not observe any early complication in our series, according to these aforementioned reports, first 5 days seem to be the critical time

period for possible complications, thus, require close follow-up.

Empiric antibiotics are the only therapeutic option for patients with TPP who develop persistent fever or leukocytosis, or for those who exhibit radiographic changes or any other signs of infection. A patient may develop mild fever and leukocytosis as a result of resorption of the cystic cavity or blood clot, but this should not be misinterpreted as superimposed infection [11]. Simple infected TPPs can be drained percutaneously [19, 21]; however, surgical treatment should be considered for complex TPPs [19, 20]. Infected TPPs do not respond to antibiotic therapy and can be life-threatening; they require aggressive treatment [19, 20]. Occasionally, disruption of a large bronchus will result in formation of a large TPP that does not resolve and may even enlarge. In such cases, closure of the bronchial connection is usually required [24]. Shirakusa et al. [16] reported patient with unresolved TPP who required middle lobectomy. One of our 52 patients with TPP required surgery to treat a pseudocyst that did not resolve and was enlarging.

While history of trauma usually facilitates diagnosis of TPP, this can also lead to confusion in certain cases. Thorvinger and Albrechtsson [25] reported a case in which a lesion originally diagnosed as TPP was resected and ultimately identified as a spindle cell sarcoma. One study that evaluated wall thickness of 65 pulmonary solitary cavities revealed that 8 % of lung cavities with a wall thickness of 4 mm or less were malignant [26]. Other authors have noted that radiographic lung manifestations may precede the clinical presentation of certain systemic conditions, such as collagen vascular disease [27]. These findings and our one case that ultimately required surgical resection underline the importance of following any persistent or growing TPP carefully until the lesion is completely resolved. If a TPP does not shrink with time, etiologies other than TPP need to be reconsidered.

Traumatic pulmonary pseudocysts can develop as a result of either blunt or penetrating chest trauma, and almost all take a benign clinical course and resolve spontaneously. Most of these lesions are not detectable on initial chest X-rays post-trauma because of superimposed contusion, however, CT is becoming widely used for initial work-up of chest trauma cases and this modality allows for clear identification of TPPs. Accurate delineation of TPP features on initial radiological imaging helps prevent misinterpretation of any follow-up films and can help the physician detect and predict complications, as well as avoid unnecessary interventions. The prognosis for TPP is good, even in patients who develop complications. Chest X-ray is sufficient for follow-up in most cases of TPP, but CT is advised in problematic cases since this modality is best for evaluating the development and resolution of these lesions.

Conflict of interest There are no conflicts of interest from H. Ulutas, M. R. Celik, M. Ozgel, O. Soysal and A. Kuzucu.

Compliance with ethics guidelines This article does not contain any studies with human or animal subjects performed by any of the authors.

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