THE OCCULT PNEUMOTHORAX (OPTX)

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Abstract: *The management of pneumothorax detected on CT but not on chest radiography remains controversial. Of 456 patients with multisystem injuries undergoing abdominal computer tomography (CT) scan, 25 patients were found to have 30 pneumothoraces and none of these were apparent on prior roentgenograms of the chest. The management of pneumothoraces detected on CT remains controversial especially in those undergoing positive pressure ventilation (PPV) who are at risk for complications regarding both observation and treatment. In this category, 24 trauma patients were enrolled. From these 24 patients, 59% were randomized to observation, 9 were submitted to drainage (41%). Overall rates of respiratory distress and mortality were similar regarding the groups of PPV patients. The determining major factor in the clinical evolution and management of these pneumothoraces was the size. Each pneumothorax was quantified by measuring its maximal width in millimetres with CT sections. Serial roentgenograms of the chest were reviewed. In the pneumothorax measuring 5*80 mm (group 1), positive pressure ventilation was of 55% and in > 5*80 mm (group 2), positive pressure ventilation was of 77%. 17% from group 1 and 85 % from group 2 had tube thoracostomy. Our results suggest that such occult pneumothoraces may be managed with close observation if they measure <5*80 mm, whether or not the patient is to receive positive pressure ventilation. Larger pneumothoraces and pneumothoraces associated with more than two rib fractures may require early treatment. All patients benefit from expiration posteroanterior chest radiograph and should be re-evaluated 24,48 hours later and on days: 7,14,21. A safe algorithm is recommended: expiration chest radiography for every patient who suffered blunt thoracic injury with at least one rib fracture detected. Close follow-up is also suggested since these entities do exist or when they cannot be ignored and their treatment suggests the early evacuation of the pleura cavity.*

Cuvinte cheie:
pneumotorace, ventilatie cu presiune pozitiva, politrauma

Rezumat: *Terapia pneumotoracelui (PT) decelat prin CT (tomografcomputer), fără a fi observat prin radiografie toracică, rămâne controversată. Dintr-un lot de 456 de pacienţi cu leziuni multisistemice, la care s-a efectuat CT abdominal, la 25 de pacienţi au fost decelate 30 de pneumotorace (PT), niciunul dintre aceştia nefiind observaţi cu ocazia radiografiei de torace efectuate de primă intenţie în urgenţă. Terapia PT decelată prin CT rămâne controversată, în special acela unde pacientul beneficiază de ventilaţie cu presiune pozitivă (VPP), ceea ce reprezintă un risc pentru complicaţii atât în cazul observării cât şi a terapiei. În această categorie au fost încadraţi 24 de pacienţi traumatizaţi. Dintre cei 24 de pacienţi, 59% au fost observaţi, 9 au fost drenaţi (41%). Procentul general al sindromului distress respirator şi al mortalităţii a fost similară vis a vis de grupele din cadrul pacienţilor cu VPP. Factorul determinant în evoluţia clinică şi terapie a acestor pneumotorace a fost mărimea PT. Fiecare PT a fost grupat, măsurând laţimea maximă în mm, cu ajutorul CT-ului, măsurarea efectuându-se pe secţiunile CT de 5 mm. Au fost revăzute radiografiile seriate ale toracelui. În PT măsurând 5*80 mm (grupa 1) în 55% din cazuri a fost realizat VPP, iar la cei cu PT>5*80 mm (grupa 2), VPP a fost necesară în 77% din cazuri. 17% din grupa 1 şi 85% din grupa 2 au beneficiat de drenaj pleural prin toracostomie. Rezultatele noastre sugerează că unele pneumotorace oculte pot fi tratate prin observaţie spitalicească dacă măsoară < 5*80 mm mărime independent de prezenţa sau lipsa VPP la pacient. PT mai mari şi PT asociate cu mai mult de două coaste fracturate necesită terapie chirurgicală precoce. Toţi pacienţii ar trebui să beneficieze de radiografie toracică în expir, antero-posterioară şi reevaluaţi după 24,48 ore, 7,14,21 zile. Se recomandă de regulă următorul algoritm: radiografie toracică în expiraţie pentru fiecare pacient suferind un traumatism toracic închis cu cel puţin o coastă fracturată. Se indică observare spitalicească atunci când aceste entităţi există sau nu pot fi ignorate şi a celor unde evacuarea pleurală precoce (imediată) este indicată.*

INTRODUCTION

OPTX is the most common life-threatening thoracic injury that can be readily treated through pleural drainage using simple technology.(9,10) Blunt chest trauma represents 70% of all thoracic injuries.(1,2) Clinical examination along with chest imaging is often sufficient for diagnosis and proper treatment.

Since thoracic trauma has a high mortality rate (20-25% of all trauma deaths), overlooked chest injuries carry

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serious consequences.(2,5) The overall care of the seriously injured patients has dramatically improved in the last several years because of improvements in diagnostic imaging, critical care, trauma systems and prehospital new philosophies of treatment such as damage-control approaches. Unfortunately, the ever increasing fidelity of topographic anatomy and subsequent greatly increased knowledge of the injured patient's anatomy has unexpectedly shown findings and conditions that were previously not recognised or contemplated in trauma care.(6,7,8) Because these conditions were unknown to preceding generations of clinicians, the appropriate therapy was often unclear.

The occult pneumothorax is a prime example of this clinical dilemma because it is the most common finding detected on CT scan after a previously "normal" chest radiography.(8) The term "occult pneumothorax"(OPTx) specifically describes a pneumothorax (PTX) that is not suspected on the basis of either clinical examination or a plain radiography, but is subsequently detected on CT.(11,12)

The OPTX occurs in about 5% of all seriously injured patients brought to the hospital and in over 50% of all PTX found in the critically injured.(13,14,15) The incidence of occult pneumotoraces is reported between 2,0 and 4,6% in patients with abdominal blunt trauma, detected with abdominal CT. In the patient with multisystemic injuries, the roentgenogram of the chest is usually obtained. After initial resuscitation in the emergency department, further evaluation of the patient may be accomplished with abdominal CT scan.

PURPOSE

We undertook a retrospective study to quantify the size of these occult pneumothoraces and to determine the criteria for their management.

METHODS

In this paper, we analysed 456 multisystem injured patients, between 1991-2011, as well as the results from the abdominal CT scans. In all patients, a roentgenogram of the chest prior to the CT scan was performed.

Definitions:

Obvious PTX were considered overt when air was visible in the pleural space as shown by a visible pleural stripe on a plain anteriposterior supine chest radiography. In the absence of this live subtle sign of PTX such as deep sulcus sign, double diaphragm sign, unusually distinct cardiac apex, visualised pericardial fat tags, depressed diaphragm, paramediastinal lucencies, or "crisp" mediastina, were not considered to represent an overt PTX.(19,20)

OPTX were classified as small, moderate or large based on a modification of a previously described OPTX scanning system.(14)

- Small OPTX were no more than 10 mm thick with a height less than 40 mm long.
- Moderate OPTX were thicker than 10 mm with a height greater than 40 mm but that did not extend posteriorly to the mid-thoracic coronal line.
- Large OPTX were thicker than 10 mm or higher than 40 mm (seen on greater than 40 or more contiguous 10 mm CT slices) and extended posteriorly to the mid-thoracic coronal line.

For the study purposes, respiratory distress was defined as an acute change from a "stable" baseline requiring the urgent placement of a chest drain on acute increase by 0,2 in the fraction of inspired oxygen. A review at the initial roentgenogram of the chest of the patients with pneumothorax detected on CT scan revealed that, in 25 patients plain roentgenograms of the chest had failed to demonstrate a pneumothorx prior to the abdominal CT scan. Among these 25 cases, abdominal CT revealed 30 unsuspected pneumothoraces, four of which were bilateral.

The hospital cause of the patients was observed to determine whether the pneumothoraces became evident on successive roentgenograms of the chest, whether they became clinically significant and whether or not tube thoracostomy was performed. In all cases it was noted whether the patient has been exposed or not to positive pressure ventilation. If the patient has had tube thoracostomy, a determination was made as to whether or not it was done prophilactically on the basis of the CT reading or for complications relating to the original chest trauma. Additional thoracic injuries detected on abdominal CT scan or roentgenography of the chest, such as pulmonary contusion, hemothorax, atelectasis and the presence and number of rib fractures were noted. The results were compared for statistical significance using the T test or Fischer's exact test.

Eligibility:

The patients were eligible for studies if they were 18 years or older, diagnosed by the attending clinical team with an OPTX identified on a chest or abdominal CT scan, were already receiving PPVC (positive pressure ventilation), had no pre-existing chest drain in situ, had no hemothorax wallouting drainage in the judgement of the attending clinician, and had no respiratory decompensation in the judgement of the attending clinician. Patients were enrolled within 6 hours of diagnosis if they were already undergoing PPV or within 6 hours of commencing PPV if they were not ventilated at the time of enrolment. Patients were excluded if they were not expected to survive, had large OPTX (because chest drainage was considered mandatory for them) or had an obvious PTX on a plain chest radiography (not occult).

RESULTS

On 456 abdominal CT scans reviewed, 25 revealed 30 pneumothoraces undetected by prior radiograph of the chest. In four cases, the pneumothorax was bilateral.

Fourteen pneumothoraces were treated with tube thoracostomy. The age of those 25 patients ranged from 18-81 years old. Eighteen patients were involved in car accidents, two were involved in motorcycle accidents, and four patients were victims of falls. A comparison of pneumothoraces treated both with and without tube thoracostomy is depicted in table no. 1, with regard to the presence of rib fractures and treatment with PPV.

Table no. 1. Association of positive pressure ventilation and presence and number of rib fractures with tube thoracostomy

	Total	PVP	With no rib fractures	1 to 2 rib fractures	> 2 rib fractures
With chest tube	15	10	8	3	4
Without chest tube	15	10	11	4	0

As seen in this table, the number of patients both with and without thoracostomy who have had PPV is not statistically different. The patients with more than two rib fractures were treated with tube thoracostomy. Tube thoracostomy was performed for three of 18 pneumothoraces measuring less than 5*80 mm. In the patients group with equal or greater to 5*80 mm (12 patients), 10 were treated with tube thoracostomy.

There is a statistically significant difference between the two groups of pneumothorax and treatment with tube thoracostomy (p=0,007). Longitudinal dimension, the number of CT scan images on which the PTX appeared, was not statistically significant (p=0,009), when studied with respect to chest tube placement. The two groups of pneumothoraces are compared in table no. 2 with respect to size, exposure to positive pressure ventilation, presence of rib fractures and treatment with thoracostomy.

Table no. 2. Association of size of pneumothoraces with PPV, presence of rib fractures and tube thoracostomy

Group	No. of PTX	Size (mm)	PTX with VPP	PTX with rib fractures	PTX with chest tubes
I	18	<5*80	10 (55%)	4 (22%)	3 (17%)
II	12	>5*80	10 (78%)	4 (37%)	10 (85%)

There is no significant difference to PPv and presence of rib fractures (p>0,2). There is a statistically significant difference between the two groups with respect to the size of the pneumothorax and chest tube drainage (p<0,0001).

In figures one and two, one can see the pneumothorax measuring 3 mm in CT and 7 mm.

Figure no. 1. Representative group 1 pneumothorax with 3 mm on CT scan

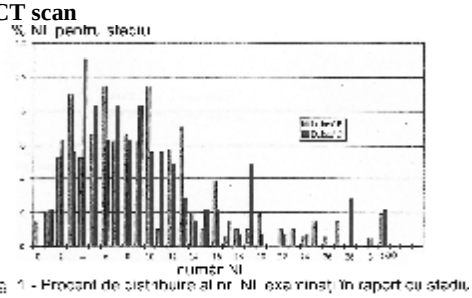
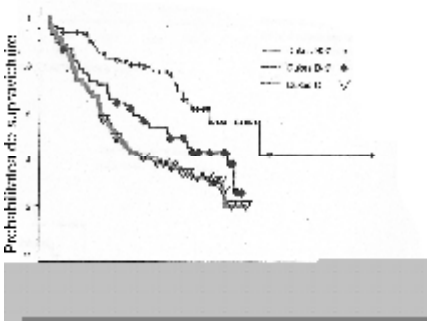


Figure no. 2. Representative group 2 pneumothorax with 7 mm on CT scan



In initial occult pneumothorax, no patients were with hemodynamic or respiratory compromise.

In the first group of patients with pneumothorax less than 5*80 mm, two chest tubes were necessary (2 patients) for increasing size of the PTX and for increasing subcutaneous emphysema.

In the second group of patients, with 5*80 mm or more size of PTX, four were prophylactically, three for increasing subcutaneous emphysema and two for increasing effusion.

In OPTX, the most frequent associated thoracic injury was chest wall muscle contusion (78,6%) and rib fracture, but in case of minor thoracic trauma in patients with polytrauma, surprisingly rib fractures were found in only a small percentage of cases (10,8%).

All patients managed with chest tube thoracostomy had an excellent outcome in respiratory functions. In OPTX right side was observed to be predominant (71%), a fact without any clinical implication.

DISCUSSIONS

Although PTX are a common and treatable cause of mortality and morbidity, there is clinical equipoise regarding the appropriate treatment of the OPTX. Based on methodologically poor evidence, some authors have recommended observation without chest drainage for all but the largest OPTX.(21,14,17,22) Although several reports have been published reviewing delayed presentation or missed diagnosis of injuries associated with blunt thoracic trauma.(3,23,24) OPTX have been studied in the literature, moreover, most of these studies were retrospective ones, and no collective prospective study is within our knowledge concerning thoracic trauma.(16,25,26) The suggested mechanism in OPTX is based mostly on valsalva mechanism, due the lung parenchyma rupture. The leak was so small that no air collection was detected on the initial inspiration chest radiograph.

According to the abovementioned observations, we recommend expiration chest radiograph upon admission for every patient with blunt chest trauma. Although CT scan proved to be a significant diagnostic tool for exclusion after ambiguous clinical and radiographic findings, it did not offer any contribution (only 0,9%) to the detection of these lesions.(2,16,27) Chest injury not apparent on the initial radiograph of the chest taken in the emergency department, by CT scan has been reported in up to 24 per cent of multisystemic injured patients.(16) Pneumothorax detected on abdominal CT scan and not detected by initial radiograph has been reported between 2,0 and 4,6% of trauma patients in our study with 456 patients with blunt trauma, 6% were found to have occult pneumothoraces. However, multisystemic injured patients are usually in the supine position, and a supine radiograph of the chest is obtained initially. In this position, the radiograph of the chest will detect most pneumothoraces large enough to require clinically tube thoracostomy.(29) In the patients in the supine position, the least dependent pleural spaces are anteromedial and subpulmonic recesses.(28,30) The air will extend laterally and apically as the volume increases or as the patient assumes a more upright position. Both the anteromedial and subpulmonic areas can be seen on the abdominal CT scan for blunt trauma (figures no. 1, 2).

Treatment of OPTX by tube thoracostomy has been reported in 43 to 82%.(29,16) Available treatment modalities can be summarized in four categories: expectant management, thoracocentesis, chest tube thoracostomy and surgical treatment.(21,16,17,31,32,33) Many authors advice the placement of chest tubes in the patients who are to undergo PPV but provide no clinical evidence in their studies to support such intervention. Our data indicate that the size of OPTX as measured by the technique described is the major determinant of management in the patients with two or less associated rib fractures. All the patients in the study with more than two rib fractures had large pneumothorax and had tube thoracostomy performed. These observations suggest for the early tube thoracostomy in these patients. In the patients with small PTX associated with more than two rib fractures, further investigation and observation are required on the first day after trauma.

PPV did not increase the need for tube thoracostomy. No patient required emergent chest tube placement because of

complications related to the initial occult pneumothorax, routine placement of chest tube is relative indicated. In the patients with conservative management of OPTX, they benefit from frequent clinical examinations and systematic periodic radiograph of the chest and the increasing size of the pneumothorax, or the development of other complications should promote for tube thoracostomy. Every patient who will be managed should be subject to expiration chest radiograph upon admission and scheduled to a strict follow-up time table that extends up to 2 weeks, which will include clinical and radiological examination of the chest even if no pathologic findings are observed at the initial examination or during hospitalization.

CONCLUSIONS

In our opinion, PTX less than 5*80 mm in size and associated with two or fewer rib fractures should be managed conservatively with close follow-up evaluation, whether or not they are to be treated with PPV. The major condition for this therapeutic option is the presence of continuous observation, monitoring and oxygen blood saturation stability. Large OPTX are likely to require tube thoracostomy, independent from the rib fractures number.

The prophylactic tube thoracostomy for PTX measuring 5*80 mm or less is not necessary to be made, and if the close observation is possible, the conservative management may be taken into consideration.

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