**Pneumothorax**
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Pneumothorax is defined as the presence of air in the pleural cavity (i.e., the potential space between the visceral and parietal pleura of the lung), which can impair oxygenation and/or ventilation.

**Different types of pneumothorax**

- **Spontaneous**
  - primary 218
  - secondary 505
  - total 723 (60.3%)

- **Traumatic**
  - blunt trauma 356
  - penetrating wounds 47
  - total 403 (33.6%)

- **Iatrogenic**
  - total 73 (6.1%)

- Total 1199 (100%)

*(Weissberg D, Refaely Y. Chest 2000; 117: 1279-85)*

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Iatrogenic pneumothorax is in principle a traumatic pneumothorax that results from injury to the pleura, with air introduced into the pleural space secondary to diagnostic or therapeutic medical intervention.

Risk of iatrogenic pneumothorax is 1.36% when performing invasive procedures (164/12,010)

- Transthoracic lung biopsy 6.7%
- Thoracentesis 3.7%
- Cannulation of subclavian vein 2.2%
- Mechanical ventilation 0.41% (in case of ARDS up to 87%)

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Figure 1. Left-sided partial pneumothorax.
164 patients with iatrogenic pneumothorax:

- Mean age 49.27 years (8 months - 93 years)
- Male 101 (61%), female 63 (39%)
- Emergency procedure 56.7%, elective procedure 43.3%
- Procedure was performed due to lung disease in 69 pt (42%), other diseases in 95 pt (58%)
- Duration of pleural drainage was mean 6 (1-46) days

Causes:

- Cannulation of subclavian vein 72 (43.8%)
- Thoracentesis 33 (20.1%)
- Lung barotrauma due to mechanical ventilation 15 (9.1%)
- Diaphragmatic injury 10 (6.1%)
- Pacemaker implantation 8 (4.8%)
- Cannulation of jugular vein 8 (4.8%)
- Pleural biopsy 6 (3.7%)
- Tracheostomy 6 (3.7%)
- CT guided transthoracic biopsy 5 (3.1%)
- Bronchoscopy 5 (3.1%)
- Others 4 (2.5%)
- TOTAL 164 (100%)


**Traumatic pneumothorax**

Traumatic pneumothorax results from blunt or penetrating chest trauma that disrupts the parietal or visceral pleura.

**Main causes:**

- Blunt chest trauma
  - Rib fractures
  - Rupture of the lung
  - Tracheobronchial rupture
- Penetrating chest injuries
  - Stab wound
  - Gunshot injury
  - Other wounds
- Oesophageal injuries
  - Iatrogenic
  - Boerhaave syndrome

**Diagnostic evaluation:**

- Air leak from the wound
- Subcutaneous emphysema
- Dyspnea, shortness of breath
- Tachycardia
- Hypotonia, extended neck veins (tension pneumothorax – pneumothorax which is a life-threatening and which develops when air is trapped in the pleural cavity under positive pressure, displacing mediastinal structures and compromising cardiopulmonary function)
- Hyper-resonance on chest percussion, decreased or absent breath sounds on auscultation (compared to the contralateral side)
Spontaneous pneumothorax

Spontaneous pneumothorax (SP) develops in people without an inciting event like coughing, trauma or physical effort.

- Primary spontaneous pneumothorax (PSP) occurs in people without underlying lung disease
- Secondary spontaneous pneumothorax (SSP) occurs in people with a wide variety of parenchymal lung diseases. These individuals have underlying pulmonary pathology that alters normal lung structure
  - COPD
  - Tumor
  - Tuberculosis
  - Cystic fibrosis
  - Catamenial pneumothorax
  - AIDS + *Pneumocystis carinii* pneumonia
    - often bilateral!
  - Other rare lung diseases:
    - Lymphangioleiomyomatosis (LAM)
    - Histiocytosis X

Incidence:

- 5-15 cases per 100,000 inhabitants per year\(^1\)
- 9.8 cases in female and 24 cases in male per 100,000 inhabitant per year\(^2\)


Catamenial pneumothorax

- Recurrent spontaneous pneumothorax in women, related to menses
- Symptoms develop 24 h before or within 72 h from the onset of menses
- 90-95% right sided


- Possible mechanisms of catamenial pneumothorax:
  - transdiaphragmatic passage of air from the genital tract through diaphragmatic perforations caused by endometrial implants
  - subpleural endometriosis (rupture of endometriotic foci during menses results in air leak and development of pneumothorax)
  - bronchiolar and vascular constriction secondary to increased levels of circulating prostaglandin F2 could be, in some cases, the source of alveolar rupture with subsequent pneumothorax


Figure 2. Intraoperative view of diaphragmatic defects in a patient with catamenial pneumothorax
Symptomatology of spontaneous pneumothorax

- Sharp pleural pain
- Dyspnea/shortness of breath
- Non-productive cough
- Tachycardia
- Subcutaneous emphysema

Symptomatology is related to the extent of pneumothorax and lung function of the patient

First symptom of pneumothorax:

- pain 66%
- dyspnea 16%  (Laisaar T. et al. ERJ 2008)

Spontaneous pneumothorax develops:

- at rest in 90% of cases
- during physical exertion in 10% of cases  (Weissberg et al. Chest 2000)

Tension spontaneous pneumothorax occurs in 1-3% of cases

- in emergency urgent decompression is needed (conversion to open pneumothorax!)

Risk of spontaneous pneumothorax is increased in:

- Smokers (risk of pneumothorax in healthy smoking male is 12% compared to 0.1% risk in non-smoker); risk is related to the intensity of smoking
- Young, tall, slim male (male female ratio 3-4 : 1)
  - Mean age 28 years (range 13-67)
    - PSP patients are younger
- Bronchial anomalies
- Marfan syndrome
- Heredity
- Development of SP is predisposed by fluctuation of the atmospheric pressure

Diagnosis of pneumothorax

- History
  - Complaints
  - Previous pneumothorax?
    - which side?
- Physical examination
  - Percussion – hyper-resonance
  - Auscultation – absence or decreased breath-sounds
• Radiological diagnostic methods
  ○ Chest X-ray:
    ▪ Standard investigation to detect pneumothorax
    ▪ It is difficult to estimate the extent of pneumothorax
    ▪ Compare consecutive investigations!
    ▪ Differential diagnosis:
      • large pulmonary cyst
      • skin folds
      • medial side of scapula
      • bandage, adhesives on the skin
      • diaphragmatic hernia

Figure 4. Recurrent spontaneous pneumothorax in a young tall man. Patient had pneumothorax on both sides.

Extent of pneumothorax
• 2 cm of pneumothorax on chest X-ray corresponds to approximately 50% lung collapse (which is large pneumothorax)
• Exact volume of pneumothorax is possible to estimate on CT
• Size of pneumothorax and symptomatology is always not in a good correlation. Treatment is therefore more determined by symptomatology and concomitant (lung) diseases (PSP versus SSP)

Further investigations to detect or detail pneumothorax?
• Computed tomography:
  ○ in complicated cases
  ○ in suspected chest tube misalignment,
- if underlying lung disease is suspected (SSP)
  - emphysema
  - other lung disease
- in patients requiring surgery
  
  \cite{tschopp2015}

- to evaluate parenchyma of both lungs
  - bullae are found in 78.6-80% 
  \cite{lesur1990,bense1993}
  - contralateral bullae are found in 53.6%
    - 26.7% of these develop contralateral SP
    \cite{sihoe2000}

![Figure 5. CT finding of pneumothorax](image)

**Treatment of pneumothorax**

Aim of the treatment is to:
- evacuate air from the pleural space
- stop the air leak from the lung
- avoid recurrence of pneumothorax

Treatment is determined by symptomatology of the patient (dyspnea) and not so much of the size of pneumothorax

**Recurrence of pneumothorax**

Recurrence usually develops during first months (6 months)

Recurrence during 5 years:
- PSP - 28%
- SSP - 43% (in case of CF up to 80%)
  \cite{baumann2000,edenborough1994}

Risk ↑ after 1. recurrence - 50%
\cite{light1990}

Contralateral pneumothorax develops in 5.2-14.6% (in adolescents up to 41%)
\cite{light1990,ikeda1988}

**Treatment methods for pneumothorax**

- Observation
  - volume of pneumothorax <15% of the hemithorax
  - at home / in hospital?
  - speed of air reabsorption is 1.25% of the hemithorax volume daily (50-75 ml)
• Oxygen (nasal cannula, mask)
  o to correct hypoxemia
  o to speed up air reabsorption from the pleural space

• Thoracentesis
  o recommended as first treatment method according to BTS guideline (2010)
    ▪ PSP in up to 75%
    ▪ SSP in up to 37% (*Baumann et al. Chest* 1997)
  o high risk of recurrence

• Pleural drainage
  o recommended as first treatment method according to CHEST (2001) guideline
  o size of the chest tube?
    ▪ expected extent of air leak
    ▪ cause of pneumothorax
    ▪ need for mechanical ventilation
    ▪ concomitant fluidothorax
    ▪ PSP: 12 Fr
    ▪ patient on mechanical ventilation: 24 Fr
    ▪ concomitant hemothorax, empyema: 24-28 Fr
  o Which is the best location to insert a chest tube?
    ▪ II intercostal space midclavicular line
    ▪ III-IV intercostal space midaxillary line
    ▪ V-VI intercostal space midaxillary line in case of concomitant fluidothorax
  o Heimlich valve / Bülau drainage / digital drainage?
    ▪ One-, two- and three-bottle collection systems
    ▪ Digital pleural drainage system
    ▪ Suction / no suction?
  o Treatment in hospital / outpatient?
  o Duration of drainage?
    ▪ 3-5 days \(\rightarrow\) surgical treatment
    ▪ air leak stops during 48h in 60% of cases, rarely later
  o Criteria to remove chest tube?
    ▪ no air leak during 24-48h versus 4-6h (advantage of digital drainage)
    ▪ drain clamping?
  o Re-expansion pulmonary edema 14-29.8%
    ▪ causes: free O2 radicals, mechanical lung injury, increase in pulmonary vascular permeability
    ▪ predisposing factors: duration of lung atelectasis > 3 days, patient age < 40 years, total lung atelectasis, fast re-expansion of atelectatic lung
    ▪ treatment: oxygen, diuretics, support of haemodynamics, mechanical ventilation when needed

• Surgical treatment
  o Indications:
    ▪ recurrent pneumothorax
    ▪ persistent air-leak > 3-5 days
    ▪ hemopneumothorax
    ▪ bilateral pneumothorax
    ▪ occupational risk
o Access to the thoracic cavity
  ▪ Videothoracoscopy

o Type of the operation
  ▪ Lung resection
    ▪ Wedge resection of bullae
    ▪ Thermo- or laser coagulation of bullae
    ▪ Pleurodesis
      ▪ chemical pleurodesis
        ▪ talcum powder
      ▪ mechanical pleurodesis
        ▪ pleural abrasion
        ▪ pleurectomy

Figure 6. Intraoperative finding of bullae at the apex of right lung in a patient with recurrent primary spontaneous pneumothorax and surgical specimen

Treatment scheme for spontaneous pneumothorax

Small ptx:  
  → thoracentesis
  → observation in hospital during 1-2 days
  ptx diminishes → discharge home
  ptx increases and/or dyspnea develops → insert chest tube

Large ptx and/or dyspnea:
  → hospitalize patient + insert chest tube
  continuous air-leak over 3-5 days → surgical treatment (VATS)

Recurrent ptx:  → hospitalize patient + insert chest tube → VATS

Chest tube: 14-18 Fr
Remove drain if: - no air-leak over 12-24 hours and
  - lung re-expanded according to chest X-ray

Literature

