THORACENTESIS (PLEURAL PUNCTURE)
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Educational objectives
What you need to know
- What is thoracentesis (pleural puncture)
- What is the purpose of thoracentesis
- Knowing the necessary materials for thoracentesis
- Identifying the site for thoracentesis
- The thoracentesis technique
- What are the potential incidents / complications; how to recognize them
- What clinical parameters should be monitored in the punctured patient

What you need to do
- Gather the necessary materials for thoracentesis
- Identify the site for thoracentesis
- Prepare the necessary materials for thoracentesis
- Perform thoracentesis
- Ensure sterile manoeuvre

Definition
Thoracentesis (pleural puncture) is a diagnostic procedure used for collecting a sample of pleural fluid from patients with pleurisy. Sometimes, the puncture is performed for evacuation purposes, for decompressing the lung from a high volume of pleural overflow. Thoracentesis is performed by the patient's bed, under local anaesthesia and must strictly comply with the aseptic technique.

Indications
- thoracentesis is performed for biochemical and cytologic diagnosis in case of a pleurisy
  - it allows differentiation between pleural exudate and transudate
  - it allows biochemical analyses of the collected fluid
- It allows cytologic and bacteriological diagnosis in the collected fluid
- Sometimes, thoracentesis is performed for therapeutic purposes, for evacuating the pleural fluid overflow compressing the lung
- Exploratory puncture is continued with inserting a drainage tube with or without active aspiration

**Contraindications**
- Known pleurisy etiology (e.g. congestive cardiac failure) or non-compressive pleurisy
  - Incapacity of bringing new diagnostic information
- When the pleural fluid volume is low, the puncture is not justified
- Hypocoagulability conditions (constitutional or related to treatment)

**Anatomy and physiology features**
- The pleural cavity normally contains a very low quantity of fluid (10-20 mL) which enables the gliding of pleural membranes during respiratory movements
- In some pathologies, a larger volume of fluid accumulates between the pleural membranes, extending the pleural cavity and compressing the lung. In an approximate X-ray assessment:
  - The opacification of the costodiaphragmatic recess means an accumulation of 100-150 mL of pleural fluid
  - The opacification of the lower half of a hemithorax means an accumulation of 1-1.5 L of pleural fluid
  - The complete opacification of a hemithorax means an accumulation of 2.5-3 L of pleural fluid
- The estimation of the pleural fluid level is made according to clinical (percussion and auscultation), radiologic (chest X-ray) and ultrasound criteria
- The puncture site is selected according to the level of pleural fluid
  - This is usually at the mid distance between the posterior axillary line and the spine
  - Usually a space lower than the upper limit of the fluid
• the intercostal space is defined as the space between the upper and lower rib; the intercostal neurovascular bundle is located on the interior side of each rib, next to the lower edge
  ○ therefore, the needle is inserted by sliding it across the upper edge of the inferior rib

![Figure 1. The needle is inserted by sliding it across the upper edge of the inferior rib](image)

**Necessary materials**

• antiseptic solution (Betadine)
• local anaesthetic: lidocaine 1% (10 mL)
• a 5-10 mL syringe with 20-22G or 25G needle and an additional 22G needle for deeper tissues – for local anaesthesia
• sterile gloves
• 2 surgical drapes
  ○ 1 fenestrated drape, preferably self-adhesive – which is applied on the patient
  ○ 1 regular drape – used for covering the surgical table
• a 20 mL syringe with thick needle (18 G)
• a container for the collected fluid
• optional: 3-way stopcock, catheter (epidural catheter)

**Technique**

*Preparation:*

• the physician introduces himself and explains the patient what is about to happen. The explanations need to include:
  ○ the name, purpose and utility of the procedure
  ○ a simple description of the procedure
  ○ the position of the patient during the procedure
• the patient must give their consent
  ○ usually, a verbal consent is sufficient
  ○ in some hospitals, this procedure requires a signed informed consent form
• the patient should be in sitting position, with their crossed elbows and forearms on a table. The back wall of the chest, the ribs and intercostal spaces are thus well exposed
if the patient cannot be put in a sitting position, the puncture shall be carried out with the patient in lateral decubitus

- the pleural fluid level is assessed through percussion; if a chest X ray has been performed, the fluid level is checked on the X ray

- palpate the ribs and intercostal spaces and choose the puncture site
  - a small sign can be marked at the chosen site

- apply Betadine on a wide area around the puncture site
  - use 3 Betadine pads successively, circular-centrifugal, according to the surgical drape preparation protocol

- put on the sterile gloves and prepare all the necessary sterile materials on a table covered with a surgical drape
  - an assistant shall open the packages and hand the materials over to the operator
  - first, cover the table with a surgical drape
  - put all the other sterile materials on this drape:
    - a fenestrated drape
    - a 5-10 mL syringe with 20-22 G needle
    - a 20 mL syringe with 18 G needle
    - 1-2 pads
    - a container for the collected fluid

- aspirate the anaesthetic into the syringe; in order to maintain sterility, do the following:
  - have the assistant hold the vial/ampoule
  - insert the needle into the vial and aspirate the contents
  - place the filled syringe on the sterile table

- apply a fenestrated surgical drape on the patient's chest, leaving the puncture site uncovered
Local anaesthesia

- inject the lidocaine 1% into the skin
  - a small quantity of anaesthetic should be injected around the upper edge of the inferior rib with the purpose of anaesthetizing the periostum
- next, insert the needle deep in perpendicular position above the upper edge of the inferior rib and inject the anaesthetic
- aspirate several times to check if the needle penetrated the pleural cavity through the parietal pleura (in which case fluid is aspirated)
  - avoid aspirating a large quantity of fluid, which would dilute the anaesthetic
  - remove the needle slowly maintaining the negative pressure within the syringe until there is no more aspirated fluid
  - at this point (with the needle next to the parietal pleura) insert the rest of the anaesthetic

The puncture

- for the proper puncture procedure, use a thicker needle (18 G) and a 20 mL syringe
- palpate the intercostal space and the adjacent ribs
- insert the needle in perpendicular position above the inferior rib adjacent to the intercostal space
  - thus, you avoid damaging the intercostal neurovascular bundle (which is located behind the lower edge of the superior rib)
• maintain negative pressure in the syringe during the entire procedure by pulling the plunger
• when the tip of the needle protrudes the pleural cavity, the pleural fluid starts flowing into the syringe
• continue aspiration until the syringe is filled
• retract the needle and apply a dressing
• at the end, the procedure is recorded in the clinical file. Write down:
  o the procedure
  o date and time of thoracentesis
  o the anaesthetic used, concentration and quantity
  o puncture site
  o the quantity and quality of the extracted fluid

**Variants**
• you may also employ Z track puncture, which prevents the formation of a fistulous track following puncture
  o insert the needle at rib level until it reaches the hip
  o slide the needle and the soft tissues upwards until the tip of the needle reaches the upper edge of the rib
  o next, insert the needle adjacently to the upper edge of the rib
• in order to avoid lung puncturing (which expands as the pleural fluid is evacuated) use a thin plastic catheter:
  o insert the needle as explained above
  o confirm through aspiration that the tip of the needle is in the pleural fluid
detach the syringe and obturate the needle with a finger in order to prevent air aspiration in the pleural cavity

- insert a soft plastic catheter through the needle and extract the needle
- once the catheter is inserted, it cannot be extracted through the needle for repositioning (the needle may break the catheter, and the distal section could be trapped in the pleural cavity)
- extract the needle holding the catheter in place
- attach the syringe and aspirate the pleural fluid
- retract the catheter and apply a dressing

- therapeutic puncture is used for extracting a larger volume of fluid, which is why several syringes should be filled with fluid. To facilitate the replacement of the syringes with the puncture needle or the catheter, attach a 3-way stopcock and use it to open/close the access to the needle/catheter.

**Incidents and accidents**

- white (dry) puncture
  - when the needle does not protrude to the fluid collection
  - small fluid quantity, secluded fluid
  - in such a situation, the needle should be inserted under ultrasound guiding
- pain
  - the parietal pleura is highly innervated; local anaesthesia might not infiltrate the pleura
- subcutaneous hematoma
  - due to the puncture of intercostal vessels
- cough

**Complications**

- pneumothorax
o rarely; favoured by uncontrolled cough during the procedure and by the use of a thick needle
o if signs of pneumothorax are present (dyspnoea, polypnoea, auscultatory silence and tympanism on the affected side) a chest X ray is performed
o if such a complication arises, perform aspiration pleural drainage

- haemothorax
  o very rarely
  o the source of the haemorrhage is usually in the intercostal neurovascular bundle

- pulmonary oedema
  o rapid evacuation of a high volume of pleural overflow is followed by the rapid reexpansion of the atelectatic lung
  o prevent complication by slow evacuation of the plural fluid

- liver or spleen damage
  o when puncture is performed in a lower intercostal space and the needle passes through the costodiaphragmatic recess and the diaphragm
  o the procedure may lead to intraabdominal bleeding

**Figure 12.**
Spleen damage – when the needle passes through the diaphragm in the peritoneal cavity

### Supervising the patient after thoracentesis

Considering complication risks following pleural puncture, monitor:

- general status
- respiratory parameters
  o respiratory rate and amplitude
  o skin colouring (=> cyanosis)
  o \( \text{SaO}_2 \)
- haemodynamic parameters
  o BP and pulse and possibly CVP
  o skin colouring (=> whiteness)
(Self-)Assessment form

<table>
<thead>
<tr>
<th>Stage/Criterion</th>
<th>Correct</th>
<th>Incorrect</th>
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</thead>
<tbody>
<tr>
<td>Explain the procedure and position to the patient</td>
<td></td>
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<tr>
<td>Choose the site for the puncture and prepare the surgical drape</td>
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<tr>
<td>Prepare the necessary materials</td>
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<tr>
<td>cover the table with surgical drape</td>
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<tr>
<td>Put the necessary materials on surgical drape</td>
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<tr>
<td>fenestrated drape</td>
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<tr>
<td>a 5-10 mL syringe with 20-22 G needle</td>
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<td>1-2 pads</td>
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<tr>
<td>a container for the collected fluid</td>
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<tr>
<td>aspirate the anaesthetic in the syringe</td>
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<tr>
<td>apply a sterile fenestrated surgical drape on the chest of the patient</td>
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<tr>
<td>Perform local anaesthesia</td>
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<td>Perform thoracentesis</td>
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<td>insert the needle</td>
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<td>adjacent with the upper edge of the lower rib</td>
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<td>directly or in Z track</td>
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<td>maintain negative pressure.</td>
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<td>aspirate the pleural fluid</td>
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<td>extract the needle</td>
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<td>apply dressing</td>
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<td>Write down the procedure in the clinical file</td>
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<tr>
<td>Strictly comply with the sterile protocol!!!</td>
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Appendix - Laboratory testing of collected pleural fluid

- characteristics of normal pleural fluid:
  - transparent
  - pH 7.60-7.64
  - protein content under 2% (< 2 g/dL)
  - glucose level similar to blood glucose level
  - WBC < 1000/mm³
  - LDH < 50% of plasmatic level

- Rivalta reaction
  - is used to differentiate exudate (positive reaction) from transudate (negative reaction)
  - acetic acid is pipetted in the extracted pleural fluid
  - if the drop dissipates in the liquid, the reaction is negative (=> transudate)
  - if the drop persists and stays at the surface of the liquid or if it floats in the fluid, the reaction is positive (=> exudate)
    - the aspect is conditioned by the precipitation of fibrinogen and of several acute phase proteins

- other differentiation criteria between exudate and transudate include:
  - the protein level in the pleural fluid and serum
  - LDH level in the pleural fluid and serum

<table>
<thead>
<tr>
<th></th>
<th>exudate</th>
<th>transudate</th>
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<tbody>
<tr>
<td>proteins in fluid</td>
<td>&gt; 50% of serum value or &gt; 2.9 g/dL</td>
<td>&lt; 50% of serum value or &lt; 2.9 g/dL</td>
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<tr>
<td>LDH in fluid</td>
<td>&gt; 60% of serum value</td>
<td>&lt; 60% of serum value</td>
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- bacteriologic examination – if the fluid is an exudate or purulent
  - Gram, Ziehl-Nielsen staining
  - culture

- glucose level
  - a low level (30-50 mg/dL) suggests a malignant cause or tuberculosis (the glucose is consumed by malignant cells or by tuberculosis bacilli)

- cytologic examination
- Lymphocytes >85% - suggest tuberculosis, a lymphoma, sarcoidosis
- Lymphocytes 50-70% - suggest a malignant etiology
- Mesothelial cells are usually present
  - When the level is > 5%, the tuberculosis diagnosis is unlikely
  - The increase of mesothelial cell counts in the fluid suggests pulmonary embolism
- Atypical cells indicate a malignant cause
- Culture