Lines and tubes: A systematic overview of line positioning in chest radiographs of intensive care unit patients

Poster No.: C-2305
Congress: ECR 2015
Type: Educational Exhibit
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Keywords: Anatomy, Thorax, Vascular, Digital radiography, Safety, Complications, Education, Acute, Foreign bodies, Education and training
DOI: 10.1594/ecr2015/C-2305

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Learning objectives

- To provide the radiologist with an overview of the variety of lines they may come across when reporting intensive care unit chest radiographs.
- To review the regional chest anatomy, correct positioning of lines and tubes, and the clinical consequences of line malposition.
- To illustrate that lines and tubes may vary in appearance depending on the manufacturer.

Background

The chest radiograph remains the most common radiological investigation in daily clinical practice. It is heavily used in the intensive care setting and is of special value in confirming positioning of lines and tubes in critically ill patients. A good knowledge of regional chest anatomy and an appreciation of the technical challenges of portable radiography are essential for correct interpretation.

There is a number of line and tube types and models, and it is important to distinguish between these radiologically. Table 1 provides an overview of the lines and tubes encountered, their optimum position, and associated complications.

Images for this section:
<table>
<thead>
<tr>
<th>Line/Tube</th>
<th>Purpose</th>
<th>Best position of tip</th>
<th>Complications of malposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central venous catheter</td>
<td>Right atrial pressure monitoring, administration of fluids/drugs/nutrition, haemodialysis</td>
<td>Superior vena cava or brachiocephalic vein</td>
<td>Pneumothorax, arrhythmia</td>
</tr>
<tr>
<td>Endotracheal tube</td>
<td>Assisted ventilation</td>
<td>5-7 cm above carina</td>
<td>Lung collapse, pneumothorax, oesophageal/tracheal rupture</td>
</tr>
<tr>
<td>Tracheostomy tube</td>
<td>Long term assisted ventilation</td>
<td>Midway between carina and stoma</td>
<td>Mediastinal haematoma, air leak</td>
</tr>
<tr>
<td>Nasogastric tube</td>
<td>Feeding, gastric decompression</td>
<td>At least 10 cm beyond the gastro-oesophageal junction</td>
<td>False feeding, pneumonia</td>
</tr>
<tr>
<td>Nasoenteric tube</td>
<td>Feeding</td>
<td>Beyond the pylorus</td>
<td>False feeding, pneumonia</td>
</tr>
<tr>
<td>Swan-Ganz catheter</td>
<td>Pulmonary arterial pressure monitoring</td>
<td>Past the main pulmonary trunk bifurcation</td>
<td>Pulmonary infarction, arrhythmia</td>
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<tr>
<td>Oesophageal Doppler probe</td>
<td>Descending aorta pressure monitoring</td>
<td>Mid oesophagus</td>
<td></td>
</tr>
<tr>
<td>Pleural drainage tube</td>
<td>Drainage of pneumothorax or effusion</td>
<td>Within pleural space</td>
<td>Lung laceration, bleeding, unilateral pulmonary oedema</td>
</tr>
</tbody>
</table>

**Table 1:** Optimum positions and complications of lines and tubes.
Findings and procedure details

Central venous catheters (CVCs)

CVCs can be used for a variety of purposes: right atrial pressure monitoring, haemodialysis, and administration of medications, fluids and nutrition. Malposition can occur in up to 30% of CVC insertions [1]; radiological confirmation of positioning after insertion is therefore vital.

CVCs are inserted through the internal jugular or subclavian vein into either brachochepalic vein or the superior vena cava (SVC). On the chest radiograph, the SVC commences at the level of the right first anterior intercostal space [2].

The CVC should lie distal to the last venous valve in order to ensure accuracy of right atrial pressure monitoring [Figure 1]. Possible vessels the CVC may unintentionally enter include the azygos or subclavian veins.

Care should be taken not to advance the catheter too far into the right atrium so as to minimize the risk of arrhythmias. Curving of the tip suggests entry into a side vessel or embedding into a vessel wall.

Endotracheal tube (ETT)

Endotracheal intubation is performed when the patient is unable to protect their airway and/or to assist with ventilation in respiratory failure. In neutral position, the ETT tip should lie midway between the carina and the vocal cords, i.e. 5-7 cm above the carina. The position can vary by approximately 2 cm with neck flexion/extension and 1 cm with neck rotation [3]. When the carina is not visible, medial ends of the clavicles can be used as a guide [4].

Common complications of an ETT are selective intubation of the right main bronchus and oesophageal intubation. Consequences of right main bronchial intubation are left lung collapse [Figure 2]. Oesophageal intubation should be clinically suspected when there is lack of chest wall expansion, or air rushes over the epigastrium are heard [5]. Radiological signs of oesophageal intubation include ETT tip lateral to the trachea, gastric/oesophageal distension with air, and tracheal deviation by the inflated cuff [6].

Tracheostomy tube
When long term ventilation is likely, a tracheostomy is used to prevent long term complications of endotracheal tube. Unlike an ETT, the tracheostomy tip position does not vary with neck movement.

On a chest radiograph, the side walls of the tracheostomy tube should be parallel to the tracheal walls. The tip should be located several centimeters above the trachea. Complications include haemorrhage (seen as widening of the mediastinum) and air leak (seen as increasing subcutaneous or mediastinal air). A small amount of mediastinal air immediately post procedure is normal [7].

Nasogastric/nasoenteric tubes

The nasogastric (NG) tube is used either for nutrition (thinner, more flexible) or gastric decompression (wider, more rigid). The tip of the tube is usually radioopaque for easier detection [Figure 2]. There are, however, radiolucent NG tubes where only the tip is radio opaque [Figure 3].

Common malpositions of the NG tube are: not far in enough, too far in, in bronchus/trachea, in oesophagus but curled on itself [Figure 4]. Complications include aspiration pneumonia due to false feeding, inadequate drainage, or injury to oesophagus or bronchus/lung.

Nasoenteric tubes are similar to NG tubes but are used for feeding only. They are longer and thinner, therefore more likely to curl on themselves. Optimum position is at least 10 cm beyond the gastric pylorus [2].

Swanz-Ganz (Pulmonary arterial) catheter

Swan-Ganz catheters are used to measure the pulmonary capillary wedge pressure, helping to distinguish between cardiac and non-cardiac pulmonary oedema. The tip should be in the right or left pulmonary artery, but no further than 2cm from the lateral mediastinal outline [2]. If it is placed too distally, it may cause pulmonary infarction. If it is too proximal (i.e. right ventricle), there is a risk of arrhythmia.

Oesophageal Doppler ultrasound probe

An oesophageal Doppler probe is an indirect, minimally invasive way of monitoring cardiac output by measuring the flow velocity in the descending aorta. The optimum position is determined by clear ultrasound signal, but tends to be mid oesophagus. It has a characteristic appearance on the chest radiograph which the radiologist and clinician alike should be familiar with [Figure 3].
Pleural drainage tube

A pleural drainage tube is inserted into the pleural space to drain abnormal fluid or air collections. Most have at least two side holes and a radioopaque strip along their length. The side holes can be identified on a chest radiograph as an interruption of the radioopaque line. A common malposition is a side hole outside the pleural space, i.e. within the soft tissues of the chest wall or outside the patient.

Complications associated with pleural drainage tubes include lung laceration, iatrogenic subcutaneous collections or unilateral pulmonary oedema from rapid removal of a large pleural effusion [8].

Images for this section:
Fig. 1: Thoracic veins and their valves.
Fig. 2: Selective intubation of right main bronchus, resulting in complete left lung collapse (left image). Subsequent repositioning achieved good reinflation with minor residual lower zone atelectasis (right image). Of note, the patient also has a radioopaque nasogastric tube.
Fig. 3: This patient had a radiolucent NG tube inserted alongside an oesophageal Doppler probe already in place. Note the radiodense NG tube tip within the stomach. An internal jugular CVC is also present.
Fig. 4: The NG tube has curled on itself in the mid oesophagus.
Conclusion

It is important for the radiologist to be aware of the different appearances of commonly encountered lines and tubes in intensive care settings, as incorrect positioning of these devices is often not clinically apparent. A good knowledge of the regional anatomy and of different types of lines and tubes aids early identification and prevention of iatrogenic complications.

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References


