Chest radiology in the ICU: Lines, Tubes, & Drains

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Objectives

To understand the *importance of chest radiograph* in the evaluation of commonly used support devices in the ICU setting

To review the *normal positions* of various indwelling devices and *relevant anatomy*

To ensure recognition of *misplaced devices* and *common complications*
Our patient: clinical presentation

- 40 year old female POD#2/1 s/p distal pancreatectomy and splenectomy for a mucinous cystic neoplasm, urgent ex-lap for bleeding, now with *persistent hypoxia*

- You order a *portable AP chest film* as the first step in your work-up
Our patient: ETT, NGT, drain on CXR

ETT
NGT
Surgical drain below the diaphragm

But, it’s difficult to assess the exact location and course of these devices.

Let’s take a look at the post-augmentation film.
Our patient: ETT, NGT, drain on augmented CXR

ET tube misplaced in the right mainstem bronchus with resultant LLL atelectasis

NGT with tip residing in stomach

Surgical drain residing below the diaphragm

Image: PACS, BIDMC
Limitations of CXR in the ICU

- Standard PA film is rarely taken, usually replaced by AP film
  - Magnified views of heart and mediastinum
- **Supine position** alters the physiology of the pulmonary vasculature
  - Blood diverted to lung apices
- **Inspiratory effort** is usually limited
  - Difficult to assess for atelectasis, pulmonary edema
- **Comorbid cardiopulmonary disease** can obscure the picture
- **Numerous support devices** can add to the confusion
Role of CXR in the ICU

- Low sensitivity and specificity
  - But, as much as 65% of ICU chest radiographs reveal a significant pathology that may change patient management (Khan et al., 2009)

- Current ACR recommendations:
  - “CXR should be obtained immediately following placement of indwelling tubes, catheters and other devices to check the position and detect procedure related complications.”
  - Of note, “daily chest radiographs should not be obtained on patients with acute cardiopulmonary problems and those receiving mechanical ventilation.” Follow-up radiographs should be obtained only for specific clinical indications.

- Study by Bekemeyer et al. found that 27% of newly placed devices were improperly positioned
  - 6% resulted in a radiographically visible complication of the intervention
Agenda

- Endotracheal tube
- Tracheostomy tube
- Thoracostomy tube
- Nasogastric tube
- Central venous line
- Pediatric vascular lines
  - Umbilical venous catheter
  - Umbilical arterial catheter
Endotracheal Tube (ETT)

- Used for mechanical ventilation
- Correct location with neck in neutral position:
  - Tip 5-7 cm above carina
  - Tip at the level of T4-5, or roughly, at medial ends of the clavicle above aortic knob
- "The hose goes where the nose goes"
  - With neck flexion, tube can descend as much as 2 cm
  - With neck extension, tube can ascend as much as 2 cm
- Inflated cuff should fill, but not bulge tracheal wall
- ETT initially misplaced in about 10% patients (Khan et al., 2009)

Image: HiSupplier

Schematic of ETT tip with neck positioning

“The hose goes where the nose goes”
Risk of extubation, laryngeal injury, uneven ventilation, slippage into pharynx or esophagus causing gastric air distention, reflux of gastric contents, aspiration

Image: Khan et al.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2700481/
Companion #2: Right mainstem intubation with left lung collapse on CXR

- More common than left mainstem intubation due to vertical orientation of right mainstem bronchus
Companion #3: Esophageal intubation with distention of esophagus and stomach on KUB

Image: Sanjay N. Jain
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3190489/
Companion #4: Complication of prolonged ETT with tracheal stenosis on chest CT

Can rarely see tracheal rupture, abscess, or hematoma

Image: Khan et al.  
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2700481/
Tracheostomy Tube

- Used for long-term mechanical ventilation
- Correct location: *Tip at the level of T3*
- Tube *should not move* with neck flexion or extension unlike ETT
- Diameter of tube should be 2/3 that of the trachea
- Again, inflated cuff should fill, but not bulge tracheal wall

Image: MDA

Companion #5: Traumatic tracheostomy tube placement on CXR

Tracheostomy tube in appropriate position with subsequent pneumothorax, pneumomediastinum, subcutaneous emphysema, deep cervical emphysema

Image: Sanjay N. Jain
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3190489/
Thoracostomy tube

- AKA pleural tube, chest tube, intercostal drainage tube (ICD)
- Used to *drain air, fluid, or pus*
- Correct location: In between visceral and parietal pleural surfaces
  - *For pleural effusion: directed posteroinferiorly*
  - *For pneumothorax: directed anterosuperiorly*
- Side holes appear as interruption in the radiopaque outline of tube on CXR
  - Should not lie outside the pleura or in the lung parenchyma
- Tube should not float above the effusion like a “lotus in the pond”
- Chest tube *malposition* occurs in about 10% of patients, rendering the tube malfunctioning or nonfunctioning (Jain, 2011)

Image: St. Joseph’s Hospital
http://krames.sjmctx.com/HealthSheets/3,S,88979

Companion #6: Right pneumothorax on CXR
Companion #6: Right pneumothorax s/p pigtail placement on CXR

- Re-expansion of right lung with residual mid-lung atelectasis
Companion #7: Low-lying ICD on CXR

- Moderate right-sided pleural effusion and malfunctioning ICD due to abnormally low position

Image: Sanjay N. Jain
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3190489/
Companion #7: Tip of ICD found within lung parenchyma on chest CT
Companion #8: ICD in high position on CXR

- Moderate right-sided pleural effusion persisting due to malfunctioning ICD in high position

Image: Sanjay N. Jain
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3190489/
Nasogastric tube (NGT)

- Used for feeding or aspiration of gastric contents
- Correct position: **Tip and side holes within gastric antrum**
- Tip should be **at least 10 cm caudal to gastroesophageal junction** to lower risk of aspiration
- Misplacement into the airway can cause pneumonia and injury to lung parenchyma
- Esophageal perforation is rare, but can occur
- **Do not routinely use chest radiograph** to confirm placement, but **ACR guidelines say must obtain if prior to first feeding**
  - Typically push air into NGT while auscultating with stethoscope over stomach to confirm position

Image: NursingFile
Companion #9: NGT coiled in upper esophagus on neck films

Image: Sanjay N. Jain
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3190489/
Companion #10: NGT coiling in left main bronchus with tip in RLL bronchus on CXR

Image: Sanjay N. Jain
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3190489/
Companion #11: Esophageal perforation s/p NGT placement on lateral neck film

Image: Khan et al.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2700481/
Central venous line (CVL)

- Used for hemodynamic pressure monitoring, hemodialysis, administration of meds/nutrition/ fluids, long-term venous access
- May be inserted peripherally (PICC) or more centrally, in the internal jugular (IJ), subclavian (SC), or femoral veins into the SVC
- Correct position:
  - **Tip should be distal to the junction of the IJ and SCV (level of T1) at the cavoatrial junction**, which corresponds to the lower border of the bronchus intermedius
  - Tip should not enter right atrium due to risk of dysrhythmias and perforation
  - Tip can enter other vessels with resultant perforation
- **30% of initial chest radiographs show CVL malposition** (Tocino, 1996)
- **6% risk of pneumothorax**, most commonly with subclavian approach (Dunbar, 1984)


Relevant anatomy
Companion #12: RIJ CVL in correct position and left PICC terminating in IVC on augmented CXR
Companion #13: Left-sided pneumothorax s/p left subclavian CVL insertion on CXR

Image: Sanjay N. Jain
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3190489/
Companion #14: CVL extending into SVC then azygos vein posteriorly on CXR

Image: Khan et al.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2700481/
Companion #15: Misplaced CVL coursing from left to right subclavian vein on CXR

Image: Khan et al.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2700481/
Companion #16: Left-sided CVL descending into mediastinum on CXR and fluoroscopy
Umbilical venous / arterial catheter

- Used for transfusion, hyperalimentation, blood gases / pressures / electrolytes exclusively in pediatric population
- Umbilical vein and arteries remain patent for up to 4-5 days after birth
- Correct location of umbilical vein catheter:
  - Tracks anteriorly in midline, with posterior angulation in the liver
  - Tip should be at base of right atrium or cephalad portion of IVC (at level of T8-9)
- Correct location of umbilical arterial catheter:
  - Initially dips into the pelvis to enter the iliac artery before tracking superiorly into the aorta
  - Tip can be located high at the level of T6-10 or low at the level of L3-4 to ensure it does not enter vessels supplying vital organs

Figure 15-2 Fetal circulation

Image: Education
http://www.education.com/study-help/article/cardiovascular-system-heart/
Companion #17: Appropriately positioned umbilical venous and arterial catheters on KUB

Image: Sanjay N. Jain
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3190489/
Companion #18: Umbilical venous catheter in left atrium passing through PFO, arterial catheter in aortic arch at origin of carotid artery on KUB

Image: Sanjay N. Jain
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3190489/
In summary, we have discussed the important radiologic features associated with these support devices:

- Endotracheal tube
- Tracheostomy tube
- Thoracostomy tube
- Nasogastric tube
- Central venous line
- Pediatric vascular lines
  - Umbilical venous catheter
  - Umbilical arterial catheter
Take-away Points

- Chest radiograph plays a critical role in the *diagnostic evaluation* of cardiopulmonary disease, but is also invaluable for *monitoring the various indwelling devices in ICU patients*.

- Support devices are intended to be life-saving, but *can be life-threatening* if misplaced or if complications are missed.

- A *systematic approach* of the radiographic features of the common indwelling lines, tubes, and drains is crucial for all healthcare providers.
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References


