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Role of Chest X-Ray to Assess Placement of Lines and Tubes in Intensive Care Unit

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Abstract: ***Objectives: Various monitoring and supporting devices are used in patients in intensive care unit. These devices are life saving if they are placed properly. Incorrect placement may be life threatening. Chest x ray is invaluable modality to check proper placement and follow up of these devices. Method: In this study, 157 patients in intensive care unit were radiographed using portable x ray machine and analyzed over a duration of one month. Conclusion: Chest x ray is a very handy tool to check placement of lines and tubes in patients in intensive care unit.***

Keywords: lines and tubes in patients in intensive care unit, chest x ray in intensive care unit

1. Introduction

A variety of support and monitoring devices are used in critically ill patients in intensive care unit. All these devices are intended to save patient's life but incorrect placement can prove life threatening. Therefore it is necessary to check proper placement of these devices at regular intervals to prevent life threatening complications. So role of chest X-ray becomes highly valuable in these settings.

Aim:
To know role of chest x ray in assessing placement of lines & tubes patients in intensive care unit.

Objective
To check placement of lines & tubes in critically ill patients in intensive care unit.

2. Material and Methodology

Study was conducted by using a Vision 800mA portable X ray machine in intensive care unit at tertiary care center. All patients in intensive care unit in whom lines & tubes were inserted, were radiographed using portable X ray machine. Then radiographs of these patients were analyzed to check position of lines & tubes. Study was conducted over duration of one month from September 1 2022 to September 30 2022. Total 157 patients were radiographed & analyzed.

3. Discussion

Nasogastric tube
Nasogastric tubes are frequently used for feeding, administration of medications and suctioning of gastric contents. Nasogastric tube has multiple side holes. On plain chest radiograph, tube should follow the path of esophagus; clearly bisect the carina, crossing diaphragm in midline & its tip below the left hemidiaphragm[1]. Ideally the tip should be at least 10 cm beyond the gastro-esophageal junction[2]. To check correct positioning of tube, air is pushed in the tube and simultaneously auscultation is done over stomach area.

Tube malposition is the most common complication. Other complications include incomplete insertion, tube coiling within esophagus or hypo-pharynx. Incorrect placement of tube leads to increased risk of aspiration. Inadvertent insertion into trachea & bronchi can cause pneumonia, pneumothorax, pulmonary contusion & pulmonary laceration. Secondary complications include lung abscess & empyema. Rare complications include pharyngeal or esophageal perforation[3].

Figure 1: Frontal chest x ray shows incomplete insertion of NGT. Tip of NGT is just distal to GE junction

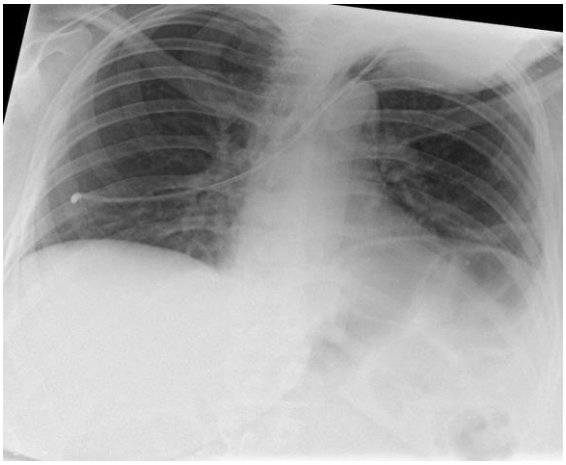

Figure 2: Supine chest x ray showing inadvertent insertion of NGT in right segmental bronchus

Endotracheal tube

Endotracheal intubation is done to maintain patency of airway or to provide artificial ventilation in hypoxic or hypoventilated patients. Endotracheal tubes are wide bore tubes with a balloon at its tip. Theses tubes come in various sizes. Balloon prevents aspiration of gastric contents into lungs. Tubes have radiopaque line on them which make them visible on radiograph.

The ideal location for tip of ETT is 5+/-2 cm above carina. It varies with the position & rotation of neck. Hence inclusion of mandible while radiographing chest for exact position of ETT becomes very helpful. In neutral position of neck, lower border of mandible will be at C5/C6 level (5 cm above carina). When neck is extended, it will be at C3/C4 level (7 cm above carina)[4] & in flexion around T1 level (3 cm above carina)[5]. In children, trachea is shorter, optimum level for tip of ETT is 1.5cm above carina. When carina is not well visualized due to technical factors, ideal position of ETT is in middle third of trachea at T2-T4 level[5].

Ideal position: Depending on position on neck,

'5 +/- 2 cm above carina'

Position of neck	Position of tube	Vertebral level
Neutral	5cm above carina	C5-C6
Extension	5+2cm above carina	C3-C4
Flexion	5-3cm above carina	T1

If the ETT is placed too high, it may cause inadvertent extubation. Hypopharyngeal intubation can cause ineffective ventilation & gastric distension. If the ETT is placed too low, it can cause selective bronchial intubation. Main stem intubation can be clinically occult in about 60% of patients and only revealed on chest x ray[6]. Right main bronchial intubation is more common. It leads to hyperinflation of right lung, segmental or complete collapse of left lung. An immediate chest x ray is warranted because these complications are not uncommon[7].If tip of ETT inadvertently inserted up to right bronchus intermedius, right upper lobe will be collapsed. Hyperinflation of balloon/ cuff of ETT can cause vocal cord injury. Long term use of these tubes may cause tracheomalacia & tracheal stenosis. During insertion of ETT, there are chances of trauma to teeth. Broken tooth may cause tooth aspiration.

One of the potential life threatening complication of ETT is esophageal intubation. In this case, ETT is seen parallel to tracheal air column or extending below carina & over distension of stomach. A right posterior oblique chest X ray is helpful in diagnosing esophageal Intubation. In this view, trachea is projected to right of esophagus showing ETT's position outside the trachea[8].

Inadvertent insertion of ETT can cause tracheal rupture on its posterior wall. Radiographically there will be subcutaneous emphysema, pneumomediatsinum, right oblique displacement of distal portion of ETT, overdistension of ETT balloon (>2.8 cm) & reduced balloon to tip distance (<1.3 cm; normal distance 2.5 cm).

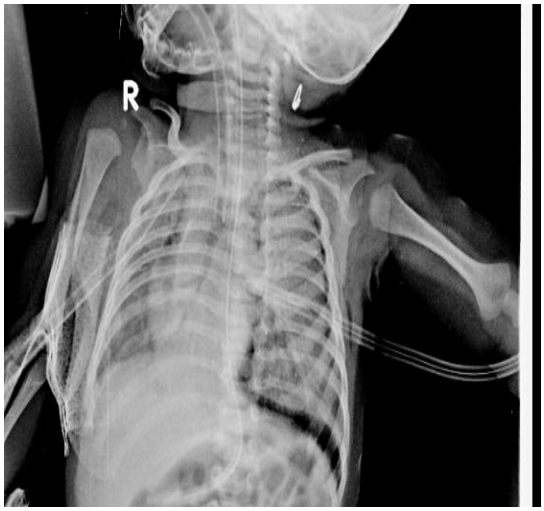

Figure 3: Chest x ray of pediatric patient showing too low intubation of ETT. Tip of ETT is very close to carina.

Figure 4: Frontal radiograph of chest showing tip of ETT in right main bronchus.

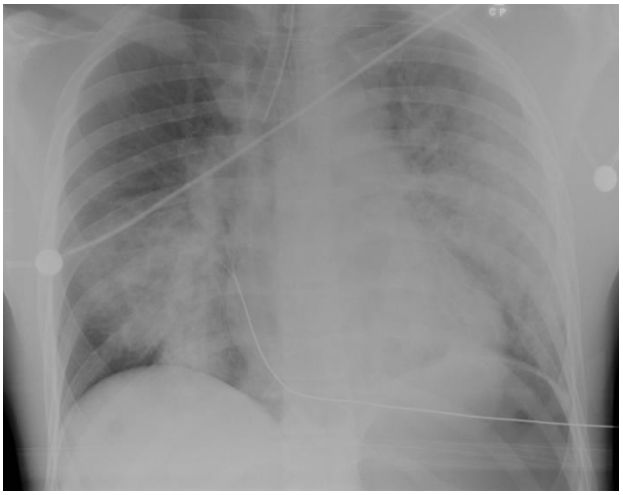

Figure 5: Chest x ray showing ETT in esophagus. Tip of ETT is outside the border of trachea i.e. in esophagus & over distended stomach.

Tracheostomy tube:

Tracheostomy tubes a.k.a. Tracheotomy tubes are used when long term intubation is required. Tip of tracheostomy tube should be at the level of midpoint between stoma & carina[9,10], at the level of D3 vertebra. Unlike ETT, it's position is maintained in neck flexion & extension also. Diameter of tube should be 2/3rd of tracheal width & cuff should not distend tracheal wall.

The possible complications include surgical emphysema, pneumothorax, pneumomediastinum, hemorrhage, false tract (paratracheal insertion) & tracheal stenosis.

Figure 6: Chest x ray showing extensive surgical emphysema over anterior abdominal wall on both sides with left sided pneumothorax with underlying collapsed lung after insertion of tracheostomy tube.

Chest tubes/Intercostal drainage tubes

Tube thoracostomy is the procedure used to evacuate air or fluid from pleural space. Tube has side holes as well as terminal holes. The side holes should always be positioned medial to inner margin of ribs. No Side hole should lie outside the chest or pleura. It has radiopaque line. Side holes can be identified on chest x ray by interruption in radiopaque line. It is inserted in 5th intercostal space in anterior or mid-axillary line. In case of pneumothorax, tip of the tube should lie between parietal pleura & visceral pleura anterosuperiorly[9,11]. While it's tip lies postero-inferiorly to drain pleural effusion or hemothorax[9,11]. In order to drain loculated pleural effusion, tip should lie well within loculated collection. After insertion, tube should not float above effusion like 'a lotus in pond'. To locate exact position of tip, both frontal & lateral CXRs are necessary.

Chest tube malposition occurs in about 10% of placements, rendering tube malfunctioning or non-functioning. Incomplete insertion of tube may result in ineffective drainage of air or fluid. Other causes of ineffective drainage include kinking of tube, intermittent blockade of tube due to debris, clotted blood etc[11]. Occasionally tube may lie in interlobar fissure or within lung parenchyma. In such cases, on chest X ray, tube has horizontal or oblique upward course & we can confirm it by lateral radiograph. Inadvertent placement of tube in extrapleural soft tissue is not uncommon.

During thoracocentesis, intercostal artery or vein may get ruptured leading to extrapleural hematoma. It appears as focal loculated area with convex margin towards lung. It will not change its configuration with change in patient's position.

Re-expansion pulmonary edema is uncommon complication. It is due to rapid lung expansion due to drainage of large pneumothoraces & large volume pleural drainage. Usually it is found in young patients & patients in whom lung has been collapsed for over 7 days[12]. Chest X ray findings include alveolar opacities, usually unilateral in those segments or lobes of lobes which were previously involved[13]. Rarely it can develop in contra lateral lung.After removal of chest tube, residual thickened pleura or parenchymal line may be seen on CXR. This line should not be mistaken for pneumothorax.

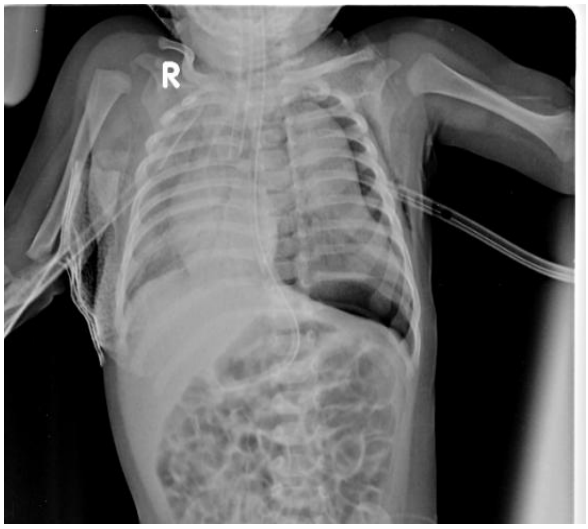

Figure 7: Frontal radiograph of chest shows ICD tubes in a patient with bilateral pneumothorax. Right sided ICD tube is directed anterosuperiorly while left sided ICD has not pierced parietal pleura (misplaced) with left sided pneumothorax and underlying lung collapse.

Figure 8: Chest x ray shows misplaced ICD tube on right side. Tip of tube is directed posteroinferiorly. Right sided pneumothorax with underlying lung collapse is seen.

Figure 9: Frontal chest radiograph showing kinking of ICD tube on right side

Figure 10: Chest x ray shows tip of ICD tube is floating above pleural effusion like 'lotus in a pond.'

Central venous catheters:

Central venous catheters are used in critically ill patients for venous access. They are usually placed via subclavian or internal jugular vein, less commonly femoral vein. Tip of CVC should be located in SVC, slightly above right atrium. On chest X ray, tip should be below anterior first rib[14,15].

Incidence of malposition of CVC is about 40%[15]. A misplaced CVC may have its tip terminating in the right heart or in central systemic veins, such as the azygous and internal jugular veins [16]. A catheter in azygous vein may be seen looped within SVC at the level of junction of trachea & right main bronchus. This can be confirmed by lateral chest radiograph showing SVC coursing posteriorly along the arch of azygous vein. More unusual abnormal positioning include placement of CVC in superior intercostal vein, internal mammary vein, inferior thyroid vein or even in subclavian artery.

Pneumothorax is second most frequent acute complication of CVC insertion occurring in up to 5% of all line placements[15]. Therefore chest radiograph becomes very important after any attempt of CVC placement. So after CVC placement, upright or contra-lateral lateral decubitus radiograph should be done to rule out small pneumothoraces which could eventually become larger, particularly patients on positive pressure ventilation.

Another life threatening complication of CVC insertion is vascular perforation. On chest radiograph, it will be seen as unusual trajectory of catheter, newly developed pleural effusion (hemothorax), mediastinal widening due to mediastinal hematoma[14].Other complications include knotting, looping, kinking. Prolonged catheterization may cause venous thrombosis and may lead to pulmonary embolism. Catheter may get compressed between first rib & clavicle. On chest radiograph it looks like catheter deviation with luminal narrowing or discontinuity of tube. This is designated as 'pinch off syndrome'.

Figure 11: Frontal chest radiograph shows misplaced central line through right subclavian vein , coiling into right IJV.

Figure 12: Chest x ray shows right sided pneumothorax which was developed after insertion of central line through right subclavian vein

Pulmonary artery catheter:

Pulmonary artery catheters aka Swan- Ganz catheter is used to monitor circulatory hemodynamics in critically ill patients. It measures pulmonary capillary wedge pressure. This is helpful to differentiate between cardiogenic pulmonary edema from non-cardiogenic pulmonary edema. The catheter is inserted via subclavian or internal jugular vein. Ideally tip of catheter should be in right or left main pulmonary artery. It should not extend beyond proximal interlobar artery[15]. The balloon at the tip of catheter is inflated only when measurements are being obtained. Persistent inflation may lead to clot formation which may lead to pulmonary infarction. On chest radiograph, it is seen as a wedge shaped pleural based pulmonary opacity.

Other complications include misplacement, coiling, looping, knotting, pneumothorax and vascular injury. Balloon rupture and development of fistula between pulmonary artery and bronchial tree are other rare complications.

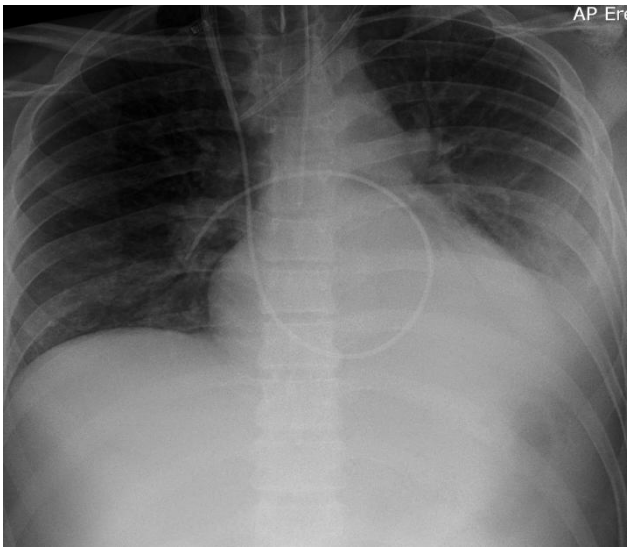

Figure 13: Chest x ray showing distal placement of pulmonary artery catheter in right interlobar artery.

4. Results

- Out of 157 placements, 39 (25%) were mal-positioned/ misplaced.
- Out of these 39, mal-positioned NGTs were 15, ETT 6, TT 3, ICDs 10, CV lines 4 & pulmonary artery catheters 1.

5. Conclusion

- Post-procedural chest radiograph & subsequent regular interval radiographs play important role in assessing position of lines & tubes & ruling out possible complications in early stage.

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