Point-of-Care Sonographic Detection of Left Endobronchial Main Stem Intubation and Obstruction Versus Endotracheal Intubation

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Objective. Determining the correct position of endotracheal tubes in critically ill patients may be complicated by external factors such as noise, body habitus, and the need for ongoing resuscitation. Multiple detection techniques have been developed to determine the correct endotracheal tube position, recently including the use of sonography to evaluate lung expansion and diaphragmatic excursion. These techniques have also been applied to diagnosis of right endobronchial main stem intubation, which may be confused with a unilateral pneumothorax in some cases. Methods. We describe the sonographic findings in a case series of endobronchial main stem intubations and obstruction, highlighting the utility of this sonographic application. Previous literature and future applications are discussed. Results. Sonographic detection of the sliding lung sign, the lung pulse, and diaphragmatic excursion can accurately detect main stem bronchial intubation as well as bronchial obstruction. Conclusions. Clinical use of lung sonography may decrease the need for chest radiography and may allow more rapid diagnosis of main stem intubation and bronchial obstruction. Key words: airway management; airway obstruction; emergency sonography; endotracheal intubation; main stem intubation.

Endobronchial main stem intubation with ventilation of a single lung is a frequent complication in critically ill or injured patients requiring endotracheal intubation.1,2 Most cases occur in the right main stem bronchus, but up to about 5% may occur in the left main stem bronchus.3 If chest radiography is delayed or unavailable, suboptimal ventilation and oxygenation in these patients may occur if the endotracheal tube (ETT) position is not promptly determined.4,5 In addition, ventilation of one lung with large volumes of gas can lead to pneumothorax or pulmonary edema.

Sonography for detection of pneumothorax has been well described in the medical literature, and some clinicians now routinely incorporate it as part of an extended focused assessment with sonography for trauma (FAST) examination.6-8 Similarly, sonography for confirmation of tracheal intubation has also been described by several authors.9-11 Two general approaches have been undertaken, with some researchers evaluating the anterior neck...
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see whether the ETT is in the esophagus.9 Alternatively, direct visualization of lung expansion via the “sliding lung sign” allows for confirmation of endotracheal intubation.10 This has also been accomplished by documenting diaphragmatic excursion on sonography.11

Although visualization of lung sliding or the countercurrent movement of the two pleural layers past each other in the most anterior portion of the chest of a supine patient is used to rule out pneumothorax, a similar finding is used to differentiate the absence of unilateral lung expansion (Videos 1 and 2).12 The lung pulse occurs when no pneumothorax is present between the two pleural layers but the sliding lung sign is not seen. What is visualized is a subtle back-and-forth pulsation that is caused by cardiac motion transmitted to the atelectatic lung, hence the term lung pulse (Video 3).13 We describe an illustrative series of cases in which sonography was instrumental in diagnosis of right and left main stem bronchus intubations as well as obstruction.

Case Descriptions

Case 1
A 32-year-old man with no medical history was brought into the emergency department (ED) by emergency medical services (EMS) after a motor vehicle collision. The patient was unrestrained and ejected from his car at high speed. On EMS arrival at the collision site, the patient was unresponsive and had poor respiratory effort. He was intubated without difficulty and brought to the ED. On arrival, blood pressure was 95/65 mm Hg, and oxygen saturation was 91% on a 100% fraction of inspired oxygen. The remainder of the physical examination revealed absent breath sounds on the right, tachycardia of 112 beats per minute, and multiple abrasions of the forehead, arms, and legs with no obvious deformities. The patient’s oxygen saturation dropped slightly to 89%, and a resident prepared to place a needle in the right hemithorax. An extended FAST examination was being performed at that time, and evaluation of the thorax with a linear transducer was completed. The left lung showed a normal sliding lung sign (Video 1), but the right lung showed absent lung sliding with a lung pulse (Video 3). This was thought to be consistent with left main stem bronchus intubation due to visualization of both pleural lines but lack of classic sliding of the two pleural surfaces past each other.

The needle thoracostomy was deferred, and preparations were made to pull back the ETT. A portable chest radiography unit was in the room, and a film was taken before any manipulation of the ETT. While the chest radiograph was being processed, the ETT was pulled back 3 cm until normal lung sliding resumed on the right on sonography and the lung pulse resolved (Video 4). The chest radiograph was available 30 minutes later and confirmed prior left main stem intubation (Figure 1). The patient also had pelvic and cervical spine films and chest, head, and abdominal/pelvic computed tomography, all of which showed negative results. His blood alcohol level was determined to be 350 mg/100 mL, and his toxicology screen results were positive for opiates and marijuana. He was admitted to the trauma intensive care unit (ICU) and extubated the following day. The patient was discharged 2 days after admission.

Case 2
An 18-year-old man with no notable medical history was involved in a motorcycle collision with no safety equipment and was intubated at the scene by EMS for poor respiratory effort, an absent gag reflex, and unresponsiveness. The patient was hypotensive en route but responded to 1 L of normal saline infusion. On physical examination, the patient had multiple contusions and abrasions over his torso, head, and extremities. There were obvious right tibia and fibula fractures, and he had decreased breath sounds on the right side. The patient’s oxygen saturation was approximately 95% with a poor waveform. Emergency medical services performed a needle thoracostomy of the right chest. On arrival, the patient’s blood pressure was 100/54 mm Hg with a heart rate of 109 beats per minute. A FAST examination showed no free intra-abdominal fluid, and a chest tube was readied. Evaluation for pneumothorax revealed the sliding lung sign on the left and a visible pleural interface on the right.
The pleural line on the right side showed a lung pulse consistent with an unventilated lung but no pneumothorax.

Delaying tube thoracostomy, the attending physician had the ETT pulled back another 2 cm, but little change was seen on sonography as the ETT was withdrawn. A decision was made to withdraw the ETT another 2 cm, backing it out to approximately 17 cm at the teeth. The patient suddenly had a return of lung sliding on the right side. His oxygen saturation slowly improved to 100%. Multiple computed tomographic studies revealed no intracranial, chest, or abdominal injury or pneumothorax. The patient’s toxicology screen results were for marijuana, opiates, and cocaine. After undergoing repair of his open tibia and fibula fractures, he left the hospital 7 days later neurologically intact.

**Case 3**

A 10-month-old girl with mosaic Down syndrome was brought from an orphanage to the ED in respiratory distress. The infant had gasping respirations with progressively poor inspiratory effort at greater than 70 breaths per minute. Her room air oxygen saturation was 91% with a heart rate of 180 beats per minute and blood pressure of 84/45 mm Hg. A 100% nonrebreather mask was immediately placed on the infant’s face. After 2 failed attempts at endotracheal intubation by the pediatric emergency physician, a pediatric anesthesiologist was summoned to the ED and successfully intubated the infant with a 2.5-mm ETT.

Point-of-care sonography was performed, which revealed good diaphragmatic excursion on the right side but no diaphragmatic motion or lung sliding on the left with visualization of a lung pulse, suggesting right main stem bronchus intubation. The ETT was withdrawn 2 cm. On repeated sonographic examination of the left lung, there was slight movement of the left diaphragm and persistence of the lung pulse. Suctioning of the infant’s airway by a catheter was performed. A third sonographic examination revealed movement of the left diaphragm equal to that of the right. The lung pulse was absent in the left lung, and lung sliding was readily apparent, implying that the lung was once again being ventilated. Chest radiography was performed, which revealed right upper lobe pneumonia and confirmed that the ETT was in the correct position. Blood was obtained for laboratory examination and culture. The patient was transferred to the pediatric ICU for respiratory failure and pneumonia.

**Discussion**

The use of point-of-care sonography for critically ill or injured patients has expanded tremendously in recent years. Applied to patients with trauma and those in the ICU, as well as in perioperative settings, it has proven to have broad utility. Lung sonography is a more recent addition to clinical sonography practice and has been effective in diagnosing not only pneumothorax but also pneumonia, lung contusions, abscesses, and other disease processes. Although sonography does not visualize the healthy lung with any detail, it does provide a good image of the visceral and parietal pleura, being especially sensitive at detecting sliding of the two layers against each other as the lungs expand and contract (Video 1). Absence of this sliding on sonography, known as the sliding lung sign, strongly supports the presence of pneumothorax and is pathognomonic if a lung point is identified. The lung point is actual visualization of the interface between the sliding lung and its absence, or pneumothorax. The sliding lung sign can be used to differentiate endotracheal

**Figure 1.** Chest radiograph showing left main stem intubation (arrow), which had been corrected 30 minutes previously on the basis of the sonographic findings.
from esophageal intubation because normal pleural sliding does not occur when air is insuffed into the stomach. Similarly, when only one lung is being ventilated, the sliding lung sign is visible only on the side with the main stem intubation. The lung pulse, first described by Lichtenstein et al, is the sonographic finding for atelectasis of the lung and can be visualized in the nonventilated lung (Video 3).

Traditionally, an unstable patient may receive a thoracostomy tube simply on the basis of physical examination, an absence of breath sounds unilaterally, and hypoxia when chest radiography is not immediately available for interpretation. Although this is acceptable, it may lead to unnecessary intervention because the physical examination can be misleading, and unilateral decreased lung ventilation may result from splinting due to broken ribs, a lung contusion, or main stem intubation in ventilated patients. Although less common than right main stem intubation, left main stem intubation may also lead to unnecessary thoracostomies in an unstable patient with trauma. Additionally, the patient in case 2 was able to avoid a chest tube, which normally would be placed automatically after a needle thoracostomy has been performed in the field. Anecdotally, it is not uncommon for needle thoracostomies performed in the field to not penetrate the chest wall completely.

Children, particularly infants, with smaller airways may be susceptible to airway obstruction from mucus plugging. In the third case, the infant had both right main stem intubation and left-sided mucus plugging. This required withdrawal of the ETI and suctioning of the airway to restore equal movement of the diaphragms, as evidenced by bilateral lung sliding and resolution of the lung pulse on the left side.

These cases illustrate the utility of point-of-care sonography for detection of main stem endobronchial intubation and airway obstruction. As more clinicians who evaluate and treat critically ill or injured patients use sonography to detect and rule out pneumothorax, evaluation of potential main stem intubation or obstruction will be another indication for which to apply point-of-care sonography. An algorithm using sonography for detection of intubation and ventilation is proposed in Figure 2.

Figure 2. Flow diagram for sonographic evaluation of the lung.

References


