CHEST

A 67-Year-Old Man With Severe Posttraumatic ARDS in Extracorporeal Membrane Oxygenation Presents Sudden Desaturation

Silvia Mongodi, MD, PhD; Marta Luperto, MD; Anita Orlando, MD; Aaron Venti, MD; Antonio Braschi, MD; Giorgio Antonio Iotti, MD; and Francesco Mojoli, MD

VIDEO

CHEST 2016; 150(6):e155-e157

A 67-year-old man is discharged from a peripheral hospital after a short stay in orthopedics for mild thoracic trauma. He is readmitted to the ED 2 hours later for severe dyspnea. His medical history includes acute myocardial ischemia and paroxysmal atrial fibrillation.

The patient is admitted to the ICU where he is first supported with CPAP and then with mechanical ventilation. Despite maximal ventilator support and pronation, gas exchanges and lung mechanics progressively deteriorate; he is addressed to our ICU for rescue venovenous extracorporeal membrane oxygenation (ECMO). At arrival, CT scan shows bilateral honeycombing pattern with diffuse thickening of interlobular septa (Fig 1); in consideration of the severe hypoxemia ($Pa{O_2}/F{IO_2}$, 45) and hypercarbia ($Pa{CO_2}$, 90 mm Hg; pH 7.2) in nonprotective mechanical ventilation (tidal volume, 290 mL, respiratory rate, 25 breaths per minute; peak pressure, 38 cm H_2O; positive end expiratory pressure, 12 cm H_2O; $F{IO_2}$, 1), venovenous ECMO is started.

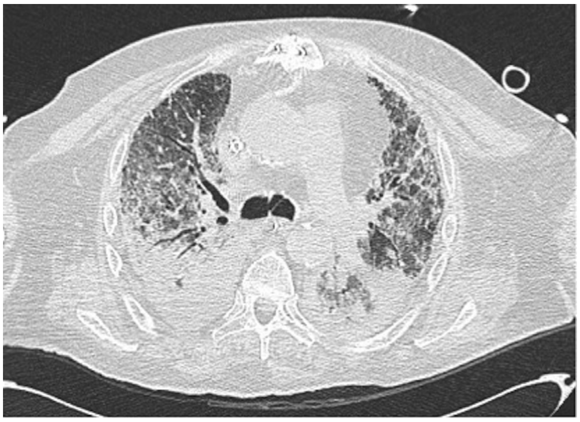

Figure 1 – *CT scan with bilateral honeycombing pattern and diffuse thickening of interlobular septa.*

Six days later, while hemodynamically stable and in ECMO with constant parameters (blood flow, 3.65 L/min; sweep gas flow, 5 L/min; $F{IO_2}$, 0.6) and in protective mechanical ventilation (tidal volume, 150 mL; respiratory rate, 8 breaths per minute; positive end expiratory pressure, 12 cm H_2O; peak pressure, 25 cm H_2O; $F{IO_2}$, 1), we observe a sudden deterioration in pulse oximetry ($Sp{O_2}$ from 98% to 80%); a newly onset thoracic asymmetry is remarked.

Question: Based on the clinical findings, what would be the logical area to examine with ultrasonography?

AFFILIATIONS: From Anesthesia and Intensive Care (Drs Mongodi, Orlando, Venti, Braschi, Iotti, Mojoli), Fondazione IRCCS Policlinico S. Matteo, Pavia, Italy; Department of Surgical, Pediatric and Diagnostic Sciences - Anesthesia, Intensive Care and Pain Therapy (Drs Luperto, Orlando, Braschi, Iotti, Mojoli), University of Pavia, Pavia, Italy.

CORRESPONDENCE TO: Silvia Mongodi, MD, PhD, Anesthesia and Intensive Care, Fondazione IRCCS Policlinico S. Matteo, Viale Golgi, 19, 27100 Pavia, Italy; e-mail: silvia.mongodi@libero.it

DOI: http://dx.doi.org/10.1016/j.chest.2016.04.040

Answer: To verify the hypothesis of barotrauma with secondary pneumothorax, lung ultrasound is done (Video 1). In right thoracic areas pleural sliding is present, with nonhomogeneous multiple B-lines and subpleural consolidations. In left anterior fields no sliding is visualized; moving laterally, a lung point is identified at the midaxillary line (in two dimensions and M-mode), confirming the diagnosis of pneumothorax.

Discussion

Lung ultrasound (LUS) has been increasingly used in clinical practice in the last years for the assessment and monitoring of acute respiratory failure[1-3]; in particular, it has high diagnostic performance for the diagnosis of pneumothorax.[4-6]

LUS is more accurate in pneumothorax diagnosis than supine anterior chest radiograph, which is still a routinely used technique but lacks in sensitivity (60%-70%).[4-6] Moreover, in pneumothorax assessment, LUS showed good correlation with CT scan, which remains the gold standard but has some drawbacks: need for transportation, irradiation, costs, and delay.[1,2] Its features make CT scan a nonsuitable tool for ventilated patients monitoring. In fact, in time-dependent settings, any delay in the provision of imaging can be deleterious[4]; LUS is therefore particularly indicated, being a bedside nonirradiating nondelayed tool.

A free pneumothorax tends to collect in anterior areas in supine patients; these will be the first fields to be examined.[1-3] Ruling out pneumothorax by LUS is simple and based on the search of three signs: lung sliding (twinkling pleural movement synchronous with breaths—confirmed in M-mode by the seashore sign), lung pulse (pulsing movement of the pleura synchronous with heartbeats, in absence of sliding—confirmed in M-mode), and B-lines (comet-tail artifacts arising from the visceral pleura and spreading up to the edge of the screen, erasing A-lines and moving synchronous with breaths).[4-6] The presence of one of these artifacts rules out pneumothorax with negative predictive value of 100%.[5,6]

Pneumothorax positive diagnosis is more technically difficult and requires the visualization of the lung point: it corresponds to the rhythmic appearance, synchronous with respiratory acts, of a normal lung pattern (lung sliding, lung pulse, or B-lines), replacing a pneumothorax pattern (static A-pattern) in a particular location of the chest wall.[6] It corresponds to the point where the collapsed lung adheres to the parietal pleura when inflated by inspiration; it is a pathognomonic sign with 100% specificity.[6] Mapping the lung point on the thorax, pneumothorax surface extension may be defined; in a recent study,[7] lung point localization also allows semiquantification: a lung point identified below the midaxillary line in supine patients predicts, with sensitivity 83.3% and specificity 82.4%, a lung collapse $> 15\%$ when compared with CT scan.

However, it is important to remember that a completely collapsed lung cannot present a lung point.

When the lung point is not visualized, the positive predictive value (PPV) of static A-pattern ranges from 55% to 98%,[8,9] depending on clinical context; in a blunt thoracic trauma, it strongly orients to pneumothorax[9].

Finally, LUS may guide chest drainage[10]: not only does it help in choosing the correct intercostal space (with static A-pattern), but it may also identify by color Doppler chest wall vessels.

As shown in the Discussion video (Video 2), a normal lung presents three typical features: visible pleura, A-lines, and pleural sliding. If a pneumothorax is clinically suspected, LUS should be performed following an algorithm (Fig 2).

The presence of real images (consolidation and effusion) rules out pneumothorax; if real structures are visible,

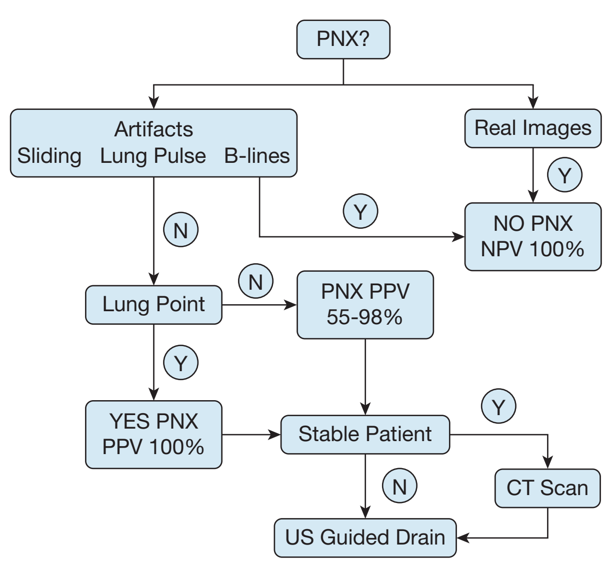

Figure 2 – *Algorithm for ultrasound-guided pneumothorax diagnosis. N = no; NPV = negative predictive value; PNX = pneumothorax; PPV = positive predictive value; US = ultrasound; Y = yes.*

although pathologic, no air is interposed between them and the probe.

Instead, the presence of artifacts should be further analyzed.

If artifacts are dynamic, pneumothorax can be excluded: the moving pleura is always the visceral one. A normal pleural sliding can be visualized in two dimensions and confirmed by seashore sign in M-mode.

An inflated but scarcely ventilated lung may not slide but feels the effect of heartbeats and presents the lung pulse; it can be confirmed by M-mode. This happens in early phase airways obstruction (well-aerated not-ventilated lung, ie, selective intubation) or in overdistension.

If no movement is visible, but B-lines are present, pneumothorax is ruled out because they derive from the visceral pleura.

The presence of sliding, lung pulse, or B-lines rules out pneumothorax with 100% negative predictive value.

If static A-lines are visualized, a pneumothorax is highly suspected; M-mode shows the stratosphere sign. It is then necessary to seek the lung point, sliding the probe laterally and/or inferiorly.

If the lung point is visualized, pneumothorax is diagnosed with a PPV of 100%. If a static A-pattern with no lung point is visualized, LUS has 55% to 98% PPV for the pneumothorax diagnosis; the same pattern may correspond to pleural adherences or emphysematous bullae, limiting the pleural movement.

Further management of pneumothorax depends on the clinical context. CT scan remains the gold standard and may be performed in stable patients to eventually investigate the actual thickness of air collection. Conversely, in clinically relevant pneumothorax or unstable patients (hemodynamic impairment and severe hypoxemia) with suggestive clinical context (ie, thoracic trauma), a chest drain should be placed.

Even when CT scan confirms the diagnosis, ultrasound remains a valuable guide for chest drain procedure.

After LUS, being that the patient is hypoxemic but stable, a CT scan is done and confirms pneumothorax; a chest drain is placed under ultrasound guidance with improvement in gas exchanges.

Unluckily, the patient's clinical status deteriorated as the diagnosis of pulmonary fibrosis was identified and the patient died 50 days later.

Reverberations

1. *LUS is an accurate bedside tool for the assessment of pneumothorax; it performs better than chest radiograph and avoids specific CT scan limitations.*
2. *Ultrasound easily rules out pneumothorax: the presence of lung sliding, lung pulse, or B-lines has 100% negative predictive value.*
3. *If a static A-pattern is visualized, the presence of a lung point should be investigated moving the probe laterally and/or inferiorly. Its identification predicts pneumothorax with 100% specificity. A completely collapsed lung has no lung point.*
4. *The region where the lung point is identified has a good correlation with CT scan percentage of collapsed lung. However, exact definition of air collection thickness is impossible, and chest drainage is determined by the clinical situation.*
5. *LUS is a valuable bedside guide for chest drain: it helps in identifying the correct intercostal space and in avoiding main chest wall vessels.*

Acknowledgments

Financial/nonfinancial disclosures: None declared.

Other contributions: *CHEST* worked with the authors to ensure that the Journal policies on patient consent to report information were met.

Additional information: To analyze this case with the videos, see the online article.

References

1. Volpicelli G, Elbarbary M, Blaivas M, et al. International evidence-based recommendations for point-of-care lung ultrasound. *Intensive Care Med*. 2012;38(4):577-591.
2. Lichtenstein DA. Lung ultrasound in the critically ill. *Ann Intensive Care*. 2014;4(1):1.
3. Bouhemad B, Mongodi S, Via G, Rouquette I. Ultrasound for "lung monitoring" of ventilated patients. *Anesthesiology*. 2015;122(2):437-447.
4. Blondeau B, Delour P, Bedon-Carte S, Saint Léger M, Chimot L. Lung ultrasound to avoid catastrophic care for false pneumothorax. *Intensive Care Med*. 2012;38(8):1410-1411.
5. Lichtenstein DA, Menu Y. A bedside ultrasound sign ruling out pneumothorax in the critically ill. Lung sliding. *Chest*. 1995;108(5):1345-1348.
6. Lichtenstein D, Mezière G, Biderman P, Gepner A. The "lung point": an ultrasound sign specific to pneumothorax. *Intensive Care Med*. 2000;26(10):1434-1440.
7. Volpicelli G, Boero E, Sverzellati N, et al. Semi-quantification of pneumothorax volume by lung ultrasound. *Intensive Care Med*. 2014;40(10):1460-1467.
8. Sperandeo M, Rotondo A, Guglielmi G, et al. Transthoracic ultrasound in the assessment of pleural and pulmonary diseases: use and limitations. *Radiol Med*. 2014;119(10):729-740.
9. Blaivas M, Lyon M, Duggal S. A prospective comparison of supine chest radiography and bedside ultrasound for the diagnosis of traumatic pneumothorax. *Acad Emerg Med*. 2005;12(9):844-849.
10. Trump M, Gohar A. Diagnosis and treatment of pneumothorax. *Hosp Pract*. 2013;41(3):28-39.