Topography of occult pneumothoraces: its importance for efficiency in diagnosis and avoiding sono-paralysis during POCUS

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Summary

Traumatic pneumothoraces remain a life-threatening problem that may be resolved quickly with timely diagnosis. Unfortunately, they are still not optimally managed. The most critically injured patients with hemodynamic instability require immediate diagnoses of potentially correctible conditions in the primary survey. Point-of-care ultrasonography (POCUS) performed by the responsible physician can be a tremendous adjunct to expediting diagnoses in the primary surgery and can typically be done in seconds rather than minutes. If more detailed sonographic examination is required, the secondary survey of the hemodynamically unstable patient is more appropriate. All involved in bedside care need to be conscious to efficiently integrate POCUS into resuscitation with the right intentions and goals to avoid sono-paralysis of the resuscitation sequence. Sono-paralysis has recently been described as critical situations wherein action is delayed through unnecessary imaging after a critical diagnosis has been made or unnecessary imaging details are sought despite an urgent diagnosis being made.

Traumatic pneumothoraces remain a problem in contemporary Canadian trauma care, having been recognized as a preventable cause of post-traumatic death that is still not optimally managed. They are common in both military and civilian experiences. The tragedy is that they are relatively simple to remediate, using simple methods that do not require formal surgical intervention, but these interventions are often not performed when indicated.[1] Pneumothoraces may be extremely easy to detect using point-of-care ultrasonography (POCUS); but integrating POCUS into the resuscitation of critically ill trauma patients is a doubled-edged sword. Here, we reflect on the justification and especially the timing related to using POCUS to detect pneumothoraces during trauma resuscitation.

Simple facts can be powerful, elegant and lifesaving in situations with life and death implications. Hefny and colleagues[2] examined thoracic computed tomography (CT) scans for the anatomic locations and volumes of blunt traumatic pneumothoraces. After applying an elegant and rigorous methodological analysis of their raw data, they arrived at nearly identical conclusions to those of our own initial investigations of this question in 2005.[3] Essentially, Hefny and colleagues determined that more than 95% of pneumothoraces in the right chest were located at the parasternal area, as were more than 97% of those on the left, and they suggested that a quick sonographic examination of the parasternal regions of both sides of the chest was the most appropriate technique for the detection of pneumothoraces in patients with blunt trauma.[2] After similarly reviewing chest CTs back in 2005, we concluded the same; namely, that most occult pneumothoraces not seen on chest radiographs, but detected only on chest CT, would be detectable at the most anterior location of the chest in supine trauma patients, which supported the recommendations of the original description of the Extended Focused Assessment with Sonography for

Trauma (EFAST) examination.[4] The original EFAST description incorporated an expedited bedside examination, with the sites of rapid sonographic examination chosen to be consistent with the recommended standard Advanced Trauma Life Support course auscultatory sites; namely, the anteromedial chest at the second intercostal space in the mid-clavicular line and of the anterolateral chest at the fourth or fifth intercostal space in the mid-axillary line. Thus, when appraised together, these reports, despite being nearly 15 years apart, are complementary and together reinforce the simple notion that air within the pleural space of critically injured trauma victims is more easily detected with an ultrasound probe than with a supine chest radiograph.[5]

It is also important to emphasize that clinical integration of all findings is always required and justifies physician- rather than technician-performed resuscitative POCUS. Although the "lung-point" sign is the single most powerful and predictive sign of a pneumothorax, a large tension pneumothorax will be too big to display the lung point, emphasizing how clinical acumen in integrating POCUS and clinical findings is essential to allowing immediate life-saving actions. We strongly believe that all involved in the care of trauma patients should appreciate these facts. Traumatic pneumothoraces are typically detectable at the most easily accessible anatomic location of the supine chest, whereas subtle pneumothoraces seen on chest radiograph are inferred from obscure findings, such as a deep sulcus sign, double diaphragm sign, unusually distinct cardiac apex, visualized pericardial fat tags, depressed diaphragms, paramediastinal lucencies, or a "crisp" mediastinum,[6,7] or not detected at all in more than half of patients with a supine chest radiograph.[8]

A pneumothorax detected on CT but not recognized by radiography has been designated as an "occult pneumothorax" (OPTX),[9] a phenomenon we would extend to pneumothoraces detected on ultrasonography but not radiography. Although OPTXs are typically not the cause of hemodynamic instability, recognizing the presence of a pneumothorax is still critical to understanding the acutely injured patient's physiology and the risks of applied therapies. A review by Roberts and colleagues confirms that positive pressure ventilation (PPV) is the the most frequent association with life-threatening tension pneumothorax and hemodynamic instability, with patients receiving PPV having adjusted odds of 12.6 (95% confidence interval [CI] 5.8–27.5) for cardiac arrest and 17.7 for hypotension (95% CI 4.0–78.4) compared with patients breathing spontaneously.[10] Further, objective evaluations reveal that OPTXs are often quite large, with no actual statistical difference between occult and "overt" pneumothoraces when carefully measured.[8,11] Thus, when an OPTX is present, especially if large, we believe it would be important to recognize it earlier than later. Even if the decision is made not to treat the OPTX at the time of diagnosis, knowing of its presence may be life-saving if instability subsequently occurs due to a tension pneumothorax.

Lung ultrasonography can be an incredibly powerful tool that greatly accelerates diagnosing life-threatening and potentially life-threatening conditions in the most critically ill patients (e.g., tension pneumothoraces[12] or pulmonary contusions[13]) within seconds if incorporated sensibly into the resuscitative process. After now attempting to incorporate bedside POCUS into the art of trauma resuscitation for more than 20 years, it has been gratifying to see lung ultrasonography evolve from being clinically ridiculed to widely accepted worldwide. However, as both lung ultrasonography in particular, and POCUS in general, have now become mainstream and expected components to emergency and resuscitative medical care, it behoves all practitioners of this art to consciously balance the needs of time-urgent diagnosis with the needs for accurate high-quality medical imaging and documentation. The more critically injured a patient is, the more they require an accurate life-saving diagnosis and the less they require high-quality, well-annotated images suitable for publication.

We recently described the phenomenon of "sono-paralysis" wherein action in a critical situation is delayed through unnecessary imaging after a critical diagnosis has been made.[14] We found no other citations or references to "sono-paralysis" when searching both the academic and "grey" literature. We did find references to delays in cardiopulmonary resuscitation related to the use of POCUS,[15–17] which could be partially ameliorated by the use of a structured algorithm for ultrasound use during cardiac arrest,[18] but we were unable to find literature pertaining to "sono-paralysis" during trauma resuscitation. This is a phenomenon that justifies more serious academic study in the future. We note that the need to prompt members of the resuscitative team to expedite POCUS examinations is not uncommon; the focus has seemingly become optimal image generation, rather than assessing the patient's anatomy and physiology in the Primary Trauma Survey. We strongly believe that POCUS should be used in the primary survey only to answer critical life-saving questions, and thereafter in stable patients POCUS can be integrated in a more comprehensive examination in the secondary survey. We believe that the term "sono-paralysis" is a new term for a poorly described but well understood concept.

Incorporating lung ultrasonography into the primary survey is intended to detect overt life-threatening pathology, not subtle findings appropriate for a secondary survey of a hemodynamically stable patient. In stable patients, comprehensive lung ultrasonography may be conducted thereafter. Such examinations may compromise the protocol of Soummer and colleagues,[19] in which each intercostal space of upper and lower parts of the anterior, lateral, and posterior regions of the left and right chest wall was carefully examined, or the BLUE Protocol of Litchenstein and Meziere[20] may be appropriate. Thus, in stable patients, as in any ultrasound examination, these areas of interrogation are suggestions, and of course the examiner should take as much time as necessary and examine as many further locations as required to obtain the best images to support a diagnosis. In unstable patients, however, lung ultrasonography can be conducted as part of the primary survey, but needs to be expedited and should focus on the original EFAST locations; namely, the anterior parasternal borders and the fourth or fifth intercostal space in the mid-axillary line, and to be always incorporated into the overall clinical context. By remembering these principles POCUS may dramatically benefit trauma care.

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