The Pleural Line

8

The previous chapters detailed the first three of the seven main principles of lung ultrasound, just evoking the four last. Now it is time to take the probe. Chapter 1 showed how we hold it and how we don't. The probe is perpendicular to the anterior chest wall and tries to stay perpendicular at the PLAPS-point.

Principle N°4 tells that in LUCI, all signs come from the pleural line. This is an apparently easy statement, but the pleural line must be carefully defined, in all circumstances, especially in agitated, dyspneic, bariatric patients, subcutaneous emphysema, and shaky environments. In bariatric patients who are agitated because of a severe pneumothorax associated with subcutaneous emphysema, all this in an airborne mission, the rules of LUCI should minimize the difficulties.

Any BLUE-protocol must begin by a correct recognition of the pleural line. We do not use transversal scans. This would make lung ultrasound more difficult, since slight movements (of physician or patient) would deeply change the image acquisition (see Fig. 1.2).

Our 5 MHz microconvex probe is perfect for this part of lung investigation.

The Pleural Line: The Basis

General Remarks

The thorax is built by the ribs and lungs. A longitudinal scan in adults makes an alternance of the rib surface on roughly 2 cm, the lung surface on roughly 2 cm, the rib on 2 cm, etc.

The rib is recognized easily: arciform hyperechoic structure and then acoustic shadow.

Between the top of 2 ribs, one can draw a "rib line."

The lung surface, i.e., the visceral pleural, is normally against the parietal pleural, and both make the pleural line in normal subjects. This is the line visible less than a cm below the rib line in standard adults. This distance is roughly 1/2 cm anteriorly, a little more posteriorly. At any age including neonates, the pleural line is located at roughly 1/4–1/3 of the distance between the two rib borders.

The pleural line appears as a hyperechoic, roughly horizontal line (when the probe is correctly applied, tangential), in actual fact slightly bended because of intrinsic distorsion of the image (visible as well with sectorial as linear probes). The pleural line should be visible in any circumstance, apart from huge surgical emphysema (Fig. 8.1).

The pleural line indicates the interface between the soft tissues (fluid-rich) of the wall and the lung tissue (gas-rich), i.e., the lung-wall interface. It shows the parietal pleura in all cases and the visceral pleura, i.e., the lung surface, only when there is no pneumothorax (nor pulmonectomy). The pleural cavity is normally virtual. The pleural line makes the parietal and visceral pleuras one line. With our 5 MHz probe, we do not distinguish the two layers, which is not a problem.

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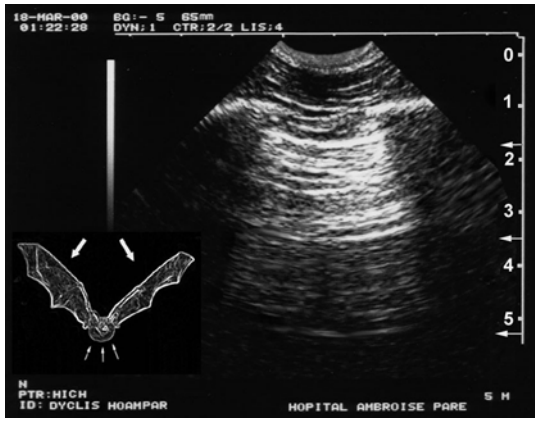

Fig. 8.1 The bat sign. The right vertical scale is centimetric. The ribs (cm 1) are recognized by their arciform shape with frank posterior acoustic shadow. A horizontal line below the rib line (1/2 cm in the adult) is highlighted (1.75 cm). This is the pleural line, which basically indicates the parietal pleura (and usually the visceral pleura). The upper rib, pleural line, and lower rib shape a kind of bat flying facing us, hence the bat sign, a basic landmark in lung ultrasonography. We made this figure without *arrow*, for keeping it preserved (see Figs. 9.1 and 10.1, for more details)

Pleural Line and the Bat Sign

The pattern created by the upper rib (left wing), pleural line (belly), and lower rib (right wing) has been labeled the bat sign, the basic first step in any lung ultrasound. It allows to precisely locate the lung surface using a stable landmark. Using longitudinal scans, the pleural line is always under control, even in hard conditions.

The concept of the bat sign avoids confusions with all other horizontal hyperechoic lines, i.e., superficial aponeuroses or deep repetition lines (A-lines, sub-A-lines, see below).

The visible length of the pleural line in adults, between two rib shadows (the belly of the bat), is roughly 2.5 cm (since the concept of a sectorial scan makes a triangular image).

In the neonate, the bat sign has exactly the same proportions (see Fig. 32.2).

The term "bat sign" appears in our publications in 2001 [1].

Variant of the Bat Sign

The "young bat sign." If the probe is applied near the sternum (inside the BLUE-points), the cartilage generates an ovoid structure that is traversed by the beam. We associated this pattern to the image of the young bat (with the idea that the bones are not yet calcified). In some cases where this may disturb (challenging examination), a shift of the probe to the outside will find the familiar landmark of the ribs.

Subcutaneous Emphysema: The Mocelin Variant

Amounts of gas invade the soft tissues in this case, and this prevents to detect the pleural line: subcutaneous emphysema is a main hindrance to LUCI. There is a possible reply. Bones are present, making a rigid deeper plan. Provided it does not harm the patient, we apply the probe with a pressure toward the rib cage in order to hide the gas. This can result in suddenly detecting an ill-defined bat sign. This sign, called the "bat in the fog," can be as precious as is the sudden detection of the runway through the fog for a stressed pilot lost in the fog (Fig. 8.2 and video 14.5).

Like in aviation rules again, the emergency can change the academic rules. In very difficult cases, to see a dynamic at the pleural line is precious, because it allows to locate precisely this pleural line (even if the ribs are not clearly visible). In other words, one uses lung sliding as a sign indicating the pleural line. This nonacademic way, called the Mocelin variant (from a Brazilian CEURFer), should be carefully used and must not be a habit, just a tool used in extreme difficulties. If we detect the pleural line *because* there is a lung sliding, this will prevent us to get accustomed to immediately detect a pneumothorax, which is, in the extreme emergency, one of the basis of LUCI. The pleural line should be recognized without any dynamic reference, only using the bat sign, as far as possible.

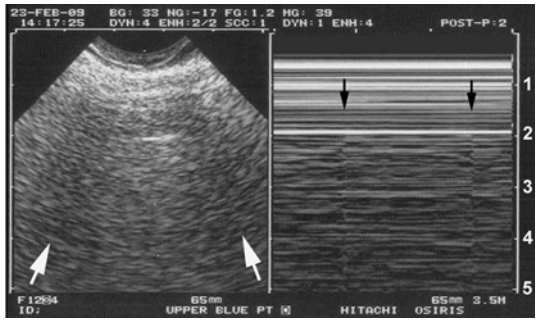

Fig. 8.2 The bat in the fog and T-lines. Many items are seen in this apparently challenging figure. This patient had a rather severe subcutaneous emphysema – after a trauma. The left image (real time) was quite impossible to interpret. After pressing the probe toward the rib cage, one has the feeling to detect ill-defined images which may correspond to acoustic shadows of the ribs (rising *white arrows*). Below what is possibly the rib line, a hyperechoic, horizontal line, ill-defined too, is visible, possibly the pleural line (2.0 cm of the right vertical scale). On the right, M-mode image, very slight accidents are visible, coming exactly from this line (*black arrows*) or, seen from *bottom to top*, stopping exactly at this line (2.0 cm of right scale). They shape the letter "T." They are definitely T-lines, i.e., an extreme equivalent of discreet lung pulse (see these terms in corresponding Chap. 10). In this really challenging file, from a traumatized patient with subcutaneous emphysema, and in spite of this extreme hindrance, one could define the rib shadows and the pleural line (the "bat in the fog") and a lung pulse. The rules of critical ultrasound make no space for confusion: there is no pneumothorax

Standardizing Lung Ultrasound: Merlin's Space

Once a probe is applied on an intercostal space and once the pleural line is identified, it is easy to build a space which has critical relevance in LUCI. This is the space located between the pleural line, the shadow of the ribs, and the lower border of the screen. It was called Merlin's space (from a question of Elisabeth Merlin, CEURFer from Oceania).

Merlin's space is normally occupied by air artifacts. Although always considered indesirable, they are under extreme attention in LUCI (principle N° 5). For the sake of rapid communication, air artifacts were given short names using alphabetic classification (we describe 12 of them at the pleural line: A-, B-, C-, F-, I-, J-, N-, O-, P-, T-, X-, and Z-lines). This is simpler than appearing at first view. Other artifacts are described above the pleural line (E-, S-, W-line), in other parts of the body (sub-B-, G-, R-, U-, V-lines), or outside the body (H-, K-lines). Most are either horizontally or vertically oriented.

All signs of LUCI arise at the very level of the pleural line (see Fig. 5.3). When the pleural layers are separated, the visceral pleura is either hidden by the air (in the case of a pneumothorax) or perfectly visible (in the case of a pleural effusion).

Standardizing Lung Ultrasound: Keye's Space

For making basic phenomena more easy to standardize, we have defined a virtual space, generated by the M-mode. The pleural line separates an upper rectangle and a lower one. This upper rectangle, limited downward by the pleural line (upward and laterally by the borders of the image), has been coined *Keye's space* (from Linda Keyes, CEURFer from Colorado) (Fig. 8.3). What happens in Keye's space is superficial to the lung.

In quiet breathing, Keye's space can be described as a stratified pattern. During dyspnea, accidents are visible within.

Just note a critical detail: the pleural line is perfectly defined without any confusion on the real-time image, using the bat sign. Using our 1992 machine (last update 2008), the pleural line is at exactly the same level, with no space for confusion, on the right M-mode image, with no lag as seen in quite all laptop machines. This means that, for searching the pleural line on the right image, one has just to continue the point where it appears (in the M-mode shooting line, supposedly at the middle) to the right image. Not configurating the modern machines this way would violate principle N°1 of LUCI: simplicity.

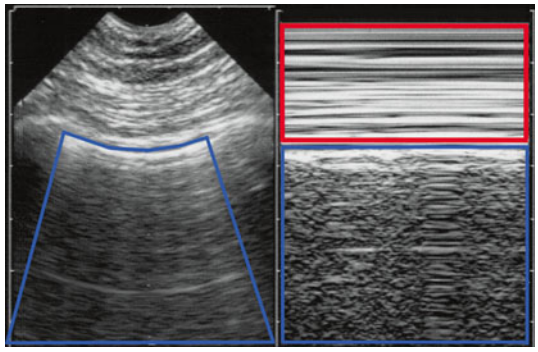

Fig. 8.3 Keye's and Merlin's space. To the left (real time), Merlin's space (*in blue*), framing what is below the pleural line (rib shadows excluded). To the right (M-mode), two spaces, separated by the pleural line, can be defined in any image of lung ultrasound. (1) An upper rectangle, Keye's space (*in red*), a virtual space, showing what is above the pleural line. (2) A lower rectangle, called for simplifying the MM-space, materializing what appears at and below the pleural line. Note this critical point: both images (*left and right*) are rigourously side by side. This will help in standardizing the field. Slightly prematurate now would be the description of the content of Merlin's space (an A-line); Keye's space (absence of dyspnea) and MM-space (lung sliding) are rich in data: the basis of the A-profile, schematically a normal lung surface

This notion, just introduced here, will have critical relevance when diagnosing pneumothorax in difficult settings. It will be developed in Chaps. 10 and mainly 14.

Standardizing Lung Ultrasound: The M-Mode-Merlin's Space

We have to define one more entity for clarifying the concept. Keye's space was defined as the upper square on the M-mode image. The lower square deserves a label. Since it corresponds to Merlin's space (real-time concept), we will label it the "M-Merlin's space." Any M-mode image in LUCI is built from two spaces, Keye's space above and the M-mode-Merlin's space below, both separated by the line materializing the pleural line (Fig. 8.3).

Reference

1. Lichtenstein D (2001) Lung ultrasound in the intensive care unit. Research Signpost Recent Res Devel Resp Critical Care Med 1:83–93