VIDEOS IN CLINICAL MEDICINE
SUMMARY POINTS

Julie R. Ingelfinger, M.D., *Editor*

Ultrasound Guidance for Pleural-Catheter Placement

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The following text summarizes information provided in the video.

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OVERVIEW

The indications for pleural drainage are diagnostic (to collect samples for cytologic, biologic, or chemical analysis) and therapeutic (to remove large fluid collections and improve respiratory function). Pleural drainage can be performed at the bedside with a single thoracentesis or, for continuous drainage, with the insertion of an intercostal drain.[1]

The use of ultrasound guidance permits selection of the best site for access to the pleural effusion, allows step-by-step, real-time visualization of the lung structures and the advancing needle, and reduces the risk associated with the procedure.[2] The introduction of ultrasonography to guide pleural-catheter placement has decreased both the cost of the total hospital stay and procedure-related risks,[3-6] since the technique facilitates the selection of the most suitable site for insertion and provides real-time visualization of the chest structures and the devices used. Lung ultrasonography may also be more accurate than chest radiography when the patient is in the supine position and may be as accurate as computed tomography (CT) for the detection of pleural effusions.[4] The safety and advantages of ultrasound guidance for pleural-catheter placement have also been confirmed in patients with cancer who have malignant pleural effusions.[7] This video demonstrates ultrasound-guided placement of a small-bore pigtail catheter for drainage of a pleural effusion.

INDICATIONS

The two most common indications for placement of a pleural catheter are drainage of the pleural space (in a patient with pleural effusion, empyema, or pneumothorax) and endocavitary administration of a drug. The ultrasound-guided insertion of a small-bore catheter is preferable to other techniques (e.g., single thoracentesis or the insertion of an intercostal, large-bore chest tube) since this approach permits continuous removal of fluid and is minimally invasive.[2]

CONTRAINDICATIONS

Before the procedure is initiated, it must be determined whether there are any major contraindications. These include coagulation abnormalities, skin infections or wounds, and skin that has been otherwise compromised. The inability to obtain a clear acoustic window with preprocedural ultrasonography is also a contraindication.

EQUIPMENT

The brightness mode, generally known as the B mode of the ultrasound unit, should be used to locate the structures of the chest and the pleural effusion. The unit should also be equipped with an appropriate probe: a convex probe with a frequency of 2.5 to 3.5 MHz or a cardiac probe with a frequency of 2.5 to 5.0 MHz. A cardiac probe is used in the video.

Drainage catheters vary in length and diameter. The diameter of the catheter used depends on the type of pleural fluid that appears to be present. A larger diameter should be used to drain an empyema or a hemothorax.

The drainage kit used in the video is equipped with an 8-French flexible pigtail catheter, a metal stiffening cannula, two fascial dilators, an echogenic blunt introducer needle with a pointed stylet, and a J-tip guidewire. The stiffening cannula facilitates the straightening of the curled tip of the pigtail catheter during insertion. The introducing needle has a pointed stylet that when removed exposes a blunt tip. The dilators facilitate gentle dilation of the tissues of the chest wall. The catheter, stiffening cannula, needle, and dilators are hollow, which allows them to slide over a guidewire, in accordance with the Seldinger technique.

To collect pleural fluid and to allow continuous in situ drainage, a large syringe, a three-way stopcock, sterile drainage tubing, a collection bag, and sterile sutures will be needed. Specimen tubes for the collection of fluid samples for culture and sensitivity analysis are also needed. Sterile gauze dressing is needed for the puncture site.

The procedure is aseptic. You will need a sterile gown and mask and sterile gloves and should follow your institution's procedures regarding hand hygiene. To prepare the patient's skin, you will need a cleansing solution, such as 2% chlorhexidine, and sterile gauze. You will also need sterile drapes and towels, a sterile sleeve to cover the ultrasound probe, and sterile ultrasound gel. To provide local anesthesia, you will need a 10-ml syringe filled with 2% lidocaine.

Before starting the procedure, place the cannula in the catheter and straighten it. Then place the stylet in the needle. Next, assemble the drainage system by connecting the drainage bag to the drainage tubing and the tubing to the stopcock. To prevent any aspiration of air, make sure that the stopcock that provides access to the patient is closed.

ULTRASONOGRAPHY OF THE THORAX

Place the ultrasound probe in a position that is parallel to the intercostal space. To obtain the best acoustic window, hold the probe firmly and perpendicular to the chest wall. Normally, the visceral and parietal pleurae are juxtaposed and move with the respiratory cycle. In contrast, the pleural effusion will appear as an anechoic space between the two pleurae.

The acoustic window should provide clear visualization of the entire ultrasound field. You should be able to identify the structures below the probe. Starting from the surface, these structures include the skin, muscles, parietal pleura, visceral pleura, and lung parenchyma. The pleural effusion appears as a space between the two pleurae. Ultrasonography can also provide quantitative and qualitative information about the nature of the fluid, since it can detect suspended particles and septate fluid collection. Adhesions or intrapleural septae increase the risk of complications, such as bleeding and injury to the lung parenchyma. In such cases, you should consider abandoning the procedure.

The volume of the pleural effusion may be estimated with the formula described by Balik et al.,[8] in which the interpleural distance is measured in millimeters and multiplied by 20, with the patient in the supine position. The volume estimated has been shown to correlate significantly ($P<0.05$) with the drained volume.[6] The use of small-bore catheters, which are generally characterized by a curled, blunt tip (hence the name "pigtail catheter"), in combination with ultrasound guidance, further minimizes trauma to tissues and increases patient comfort.

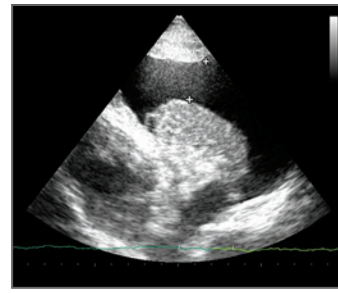

Figure 1. Ultrasound Measurement of a Pleural Effusion.

PREPARATION

If circumstances permit, explain the procedure to the patient before beginning. You should also obtain written informed consent. Coagulopathies should be ruled out; if present, they should be corrected, if possible, before the procedure is initiated. An assistant, not necessarily a physician, should always be present to help the operator prepare the equipment and to assist in positioning the patient, if needed.

Before starting the procedure, place the patient in a laterally recumbent or upright sitting position in accordance with the patient's clinical condition and in order to expose the best acoustic window. In this video, we describe a lateral–posterior approach in a mechanically ventilated patient. After positioning the patient, perform a complete ultrasound examination of the thorax.

The most suitable point of insertion is that at which the maximum width of the pleural effusion has been detected (Fig. 1). Mark the point of intended insertion with a skin marker.

In the best-case scenario, the acoustic window should show the following structures, from surface to depth: superficial structures (skin and muscles), the parietal pleura, the visceral pleura, and the lung parenchyma. The pleural effusion appears as a space (usually anechoic) between the parietal and visceral pleura, with respiratory movement of the lung within the effusion.[4] To perform the procedure safely, the width of the pleural effusion should be at least 1.5 cm.

During the examination, it is useful to consider the type of effusion. Look for suspended particles or septae floating in the mass of liquid.

Using gauze soaked in a sterile disinfectant preparation, thoroughly disinfect the skin and place sterile drapes around the selected site. Prepare the probe. With the help of a second operator, apply ultrasound gel to the probe and cover it with the sterile sleeve. Secure the sleeve to the probe. The equipment kit used in this video contains a blunt needle equipped with a pointed stylet (Fig. 2). To ensure minimal invasiveness and to prevent lung puncture when advancing the needle, remove the pointed stylet during the last passage through extrapleural structures.

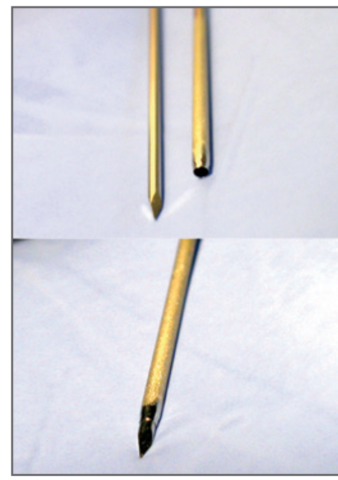

Figure 2. The Blunt Needle and Its Pointed Stylet.

PROCEDURE

Using ultrasonography, reconfirm the location of the pleural effusion in the area where the catheter is to be inserted. Maintain the position of the probe on the chest wall, and introduce the needle with its stylet to a length of 1.5 to 2.0 cm through the skin, fascia, and intercostal muscle. Once the needle tip is close to the parietal pleura, remove the stylet and connect a 10-ml syringe to the distal part of the needle.

Continue introducing the needle while gently aspirating. Identify the distal tip of the needle as it enters the interpleural space, keeping the structures below it in view (Fig. 3). Confirm the penetration of the needle into the pleural space by aspirating pleural fluid into the syringe.

Once you have reached the pleural space, disconnect the syringe and slide the guidewire through the needle into the pleural space. Confirm the intrapleural location of the wire as you visualize it with the ultrasound unit. Remove the needle and advance the dilator over the wire for half of its length, passing it through the

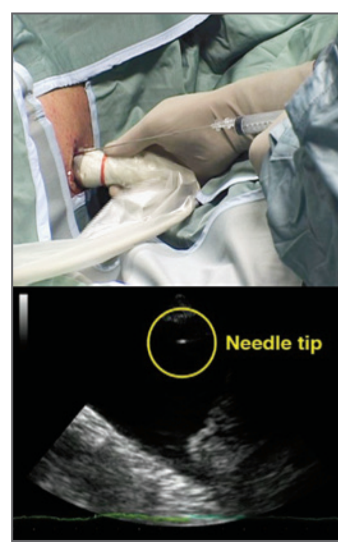

Figure 3. Identification of the Needle in the Pleural Space.

skin and the parietal structures. To advance the dilator, push it firmly but gently against the skin, twisting it as it advances.

Slide the previously assembled catheter, with the stiffening cannula in place, over the wire. Make sure that the wire extends outside the proximal part of the catheter. Then advance the catheter by half of its length — holding both the cannula and the wire firmly — to avoid any damage to the lung (Fig. 4).

Once the catheter has been inserted, completely withdraw the wire and the inner stiffening cannula simultaneously. Use your finger to close the proximal hub of the catheter, acting quickly to prevent any aspiration of air, which is a risk, particularly for patients who are breathing spontaneously. Connect the catheter to the preassembled drainage system.

Figure 4. Insertion of the Pigtail Catheter.

To drain the effusion and to introduce fluid into the drainage bag, use the syringe and the stopcock. Close the stopcock in the direction of the drainage bag and initiate drainage with the large syringe. When the syringe is full, close the stopcock to the patient and release the fluid into the drainage bag. Repeat these steps until the pleural fluid is completely drained and you feel no resistance with aspiration (Fig. 5). The collected fluid can be used for culture and other laboratory tests.

Figure 5. The Drainage System.

Allow the fluid to drain gradually in response to gravity by hanging the drainage bag on the side of the effusion, just below the patient's thorax. Before securing the catheter, make sure that all the fluid has been drained and that the effusion can no longer be detected on ultrasonography. If you see residual pleural fluid, slowly pull out the catheter by no more than half its length and begin to gently aspirate the liquid with the same syringe, as long as it is possible to drain fluid again without feeling any "pulling," or resistance, from the syringe. Repeat this procedure until the residual fluid has been removed.

Make sure that you do not withdraw the catheter too far. The curled end of the catheter and its perforations should remain within the pleural space.

If there is no residual fluid, disconnect the syringe and leave the stopcock open to allow flow from the patient to the collection bag. Be certain that you have the stopcock in the correct position. Perform a postprocedural check on the ultrasonography to confirm the success of the procedure.

Finally, make sure that all connections are secure in order to avoid accidental disconnections and the entry of air into the pleural space. Secure the catheter with a surgical suture, clean the surrounding skin, and apply a sterile dressing. Make sure that the catheter is not bent or occluded during placement of the dressing.

Dispose of all needles, syringes, and other "sharps" properly, in accordance with the policy at your institution. A standard chest radiograph should be obtained after completion of the procedure to confirm that the catheter is correctly positioned and to rule out possible complications.

In patients who are receiving positive-pressure ventilation, there is no need for a water seal if a small-bore catheter is used (up to 10-French). The small diameter of the tubing and the column of fluid itself prevent air from entering the pleural space.

The catheter can be left in place for several days to allow continuous drainage. When a simple drainage bag is used, it should be hung at a level lower than the patient's thorax so that the fluid will drain gradually, in response to gravity.

COMPLICATIONS

Complications of ultrasound-guided insertion of a pigtail catheter are few. However, injury to the lung or the vessels of the chest wall can occur during the insertion of the needle. In these situations, a hemothorax or pneumothorax may occur. Other possible complications, also rare, include puncture of intrathoracic structures or intraabdominal organs. Rapid drainage of a very large pleural effusion, particularly in a patient who is not receiving mechanical ventilation, can cause discomfort and may also cause reexpansion pulmonary edema.

Further evaluation is mandatory if the patient shows clinical deterioration or unexpected hypoxemia or if changes in the pleural effusion occur during drainage. Such changes include the presence of blood, clots, or air. In such instances, further evaluation is mandatory and a chest radiograph or CT study of the chest should be obtained. Depending on the findings, there may be a need for additional examinations or procedures, such as insertion of a chest tube or surgical revision.

SUMMARY

Ultrasound guidance is currently considered to be the safest means of positioning a pleural catheter and draining a pleural effusion.[5] This technique requires the development of skill in the use of ultrasonography and in catheter placement. Careful screening of patients for whom the procedure is appropriate, the presence of an experienced operator, and access to a detailed clinical protocol can minimize complications.

No potential conflict of interest relevant to this article was reported.
Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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and I would like to add two additional citations to Spadafora's related to intrauterine growth restriction: an article by McMinn and colleagues in 2006 that was the first to note the role of imprinted gene disruption,[1] and a recent study by Ding and Cui directly addressing the connection between intrauterine growth restriction and adult-onset diseases.[2]

Stonestrom objects to the inclusion of histone modifications and higher-order chromatin structure in the definition of epigenetic information, in that these are linked more to transcriptional regulation than epigenetic memory during cell division. This is refreshing to hear, since epigeneticists are often accused of the opposite — that is, putting too little emphasis on these factors and the transcription factors that regulate them, in favor of DNA methylation. I have written extensively about transcription factor regulation and epigenetics elsewhere in more technical articles for specialists.[3,4] That said, most of us believe that chromatin states are also regulated genetically, as supported by experimental evidence from Kadota and colleagues.[5]

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Since publication of his article, the author reports no further potential conflict of interest.

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Ultrasound Guidance for Pleural-Catheter Placement

TO THE EDITOR: The video by Peris et al. (April 5 issue)[1] illustrates their technique for pleural-catheter placement. On the basis of our experience with more than 5400 ultrasound-guided pleural-catheter placements over the past 10 years, we highly recommend a different approach. We strongly advocate the use of the "in-plane" ultrasound technique for real-time visualization of the needle during local anesthesia and catheter placement. Locating the needle tip in a transverse "out-of-plane" technique, as suggested in the text that corresponds with the video by Peris and colleagues, implies a high risk of misjudgment, since the interventionalist may mistake any cross section of the needle with the needle tip.

In ultrasound-guided pleural-catheter placement, no skin marker should be used, since it may interfere with asepsis. Local anesthesia should be applied with the use of ultrasound guidance to precisely anesthetize the skin and the parietal pleura. Also, the parietal pleura should be punctured with the use of a pointed stylet to reduce trauma. In addition, permanent in-plane ultrasound guidance allows the interventionalist to safely puncture fluid collections smaller than 1.5 cm (e.g., in patients with a septated empyema). Finally, stepwise pleural drainage is mandatory to avoid expansion pulmonary edema.[2,3]

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No potential conflict of interest relevant to this letter was reported.

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TO THE EDITOR: In the educational video about ultrasound guidance for pleural-catheter placement, the ultrasound probe is placed parallel to the intercostal space, and then the needle is introduced from the middle of the probe in a short-axis approach.[1] For thoracentesis, the needle is inserted at the top of the inferior rib to avoid injury to the intercostal artery.[2]

The needle should be inserted from the caudal side of the probe, which already occupies most of the intercostal space (especially with the use of a convex probe), to ensure advancement along the superior surface of the inferior rib. However, in the video, the needle is inserted from the cranial side of the probe. With this approach, the needle tends to pass along the inferior surface of the superior rib, where the intercostal artery lies. This is important because although ultrasound-guided pleural drainage may reduce the risk of pneumothorax and inadvertent organ puncture, it may not reduce the risk of laceration of the intercostal artery,[3] unless localization of the intercostal artery by color Doppler ultrasonography is routinely incorporated into the protocol.[4]

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THE AUTHORS REPLY: As an alternative to the out-of-plane approach that we presented, Gruber et al. and Keng and Hsieh propose an in-plane technique for monitoring advancement of the needle during ultrasound-guided pleural puncture. In our opinion, the two techniques have different indications.

With the in-plane technique, a linear probe, set to visualize the parietal tissues and the advancing needle, is preferable, although it cannot show the deep structures, and the needle is advanced oblique to the direction of the probe. This approach, which is currently used in biopsies of pleura and superficial structures, may be preferable in particular conditions such as limited or loculated effusions. However, increased technical complexity should be weighed against the expected clinical benefits.

In patients with large pleural effusions, even static ultrasound guidance with site marking performed immediately before the procedure can be considered a safe alternative to dynamic ultrasound guidance with real-time visualization of the advancing needle.[1,2] The static technique is easier to perform than the dynamic technique, since the operator is less distracted by the technical difficulty of holding both the probe and the needle.[3]

The technique we presented in our video is a compromise between feasibility and safety. In a real-time out-of-plane approach with a small-phase array probe, the needle is introduced "intuitively" in the same direction of the probe while the whole effusion and the surrounding structures are kept in sight. Any potential misjudgment of the needle tip may be regarded as a limited disadvantage, as compared with the overall safety of the procedure.

Whichever technique is used, insertion of the needle above the upper edge of the rib should minimize the risk of a lesion in an intercostal artery, but the exact position of the artery is unpredictable.[4] Other factors also should be considered, such as the laterality of the puncture site.[5] We use a needle with a conical tip that ensures a blunt dissection of tissues and a lower risk of arterial tearing than the risk associated with a sharp bevel of a "classic" cannula. Since it is not hollow, the stylet is removed, exposing a blunt tip. A syringe is connected to quickly detect penetration into the effusion. So far, we have not had a problem related to trauma to the parietal pleura caused by the blunt tip.

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Since publication of their video, the authors report no further potential conflict of interest.

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