SPECIAL TECHNIQUES IN TRANSTHORACIC NEEDLE BIOPSY OF PULMONARY NODULES

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Transthoracic needle biopsy (TNB) of pulmonary nodules requires the skills of two specialists: (1) the radiologist and (2) the pathologist. From the radiologist's perspective, the goal is very simple: to obtain a sufficient amount of material through the needle to allow the pathologist to make a diagnosis with a minimum of complications to the patient. Similarly, the goal of the pathologist is to determine quickly and accurately whether the specimen procured is adequate, thereby avoiding having the radiologist obtain additional samples that would lengthen the procedure and increase the risk of complications. The pathologist must then determine how the specimen should be analyzed to maximize yield. Special techniques in TNB are used with a view toward these goals. This article defines three distinct aspects of TNB and for each describes various techniques that we believe are helpful in enhancing them. These include placement of the needle tip within the nodule, cytologic techniques for maximizing specimen yield for immediate review, and strategies for pathologic analysis and minimizing complications.

NEEDLE PLACEMENT

One cannot achieve accurate results from TNB if the tip of the needle is not placed within the nodule. Needle misplacement probably represents the single most common cause for a false-negative biopsy. Even missing the nodule by a fraction of a millimeter is not sufficient, especially when entertaining the idea of accepting a nonspecific benign diagnosis as truly representative of a benign lesion. Each aspect in the performance of the procedure can lead to difficulties with placement of the needle and deserves attention and a reasoned approach.

Beginning with patient positioning, we have found that it is preferable to perform biopsy procedures in the prone rather than supine or decubitus position. There are several reasons for this. First, there is less motion of the posterior aspect of the ribs relative to their anterior aspect. The motion of the ribs during breathing can be thought of as analogous to the motion of “bucket handles,” with the hinges situated posteriorly. The posterior portions of the ribs rotate in place when the patient breathes but do not move in the craniocaudal plane, which is the opposite of what occurs anteriorly. With each breath, as the chest expands the rotation of the ribs causes an increase in the anteroposterior diameter of the chest as the anterior aspect of the ribs moves in a craniocaudal plane. There is less motion of the needle when using a posterior approach, because it is not deviated by the

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moving ribs. A second advantage of prone positioning is that after completion of the procedure it is preferable to place the patient with the biopsy site in the dependent position. It is generally much easier for patients to lie on their backs following the procedure than to lie on their stomachs for extended periods of time. A third advantage of a posterior approach is that when prone, patients cannot actually see the needle as it is being placed. Although this is generally not a problem, on rare occasions it can be quite upsetting to the patient.

In a review of our own work (personal data) we analyzed factors that affected the ease of performing the biopsy procedure. As a measure of ease we retrospectively reviewed over 200 cases and counted the number of CT images necessary to perform the procedure. We studied multiple variables including nodule size, depth and location, thickness of soft tissue from skin to pleura, and patient positioning. We found that each of these variables had significant impact in determining the length of the procedure. Biopsies that were easiest to perform were in thin patients with large nodules located close to the pleura with patients placed in the prone position. Conversely, the most difficult biopsies were in large patients who had small deep nodules and had to be placed in the supine or decubitus position for lesion access. Of all the variables listed, the only one that the radiologist has some discretion over is patient positioning. When the difference in distance from a supine approach to a prone approach is not very large, the prone approach is preferred. This also implies that we can shorten the duration of the procedure in this way. In general, all efforts should be made to reduce the length of the procedure, because with increasing time there is increasing tendency for the patients to move, which can lead to changes in the needle direction.

The fourth reason for preferring the prone position is that we have found less of a need to rely on breathing techniques with this approach. In general, we do not give specific breathing instructions to the patient when performing the procedure, including the time of initial pleural puncture. The patient is simply instructed to breathe gently. An exception to this is that the patient is instructed to stop breathing during the actual aspiration of the lesion when the specimen is obtained. The other exception is when the nodule is located near the diaphragm. In this circumstance the patient is instructed to take a small breath because there can be a great deal of motion and the biopsy procedure becomes analogous to "shooting at a moving target." The patient is coached before actually placing the needle to determine the location of the diaphragm so that each time they are told to stop breathing the lesion returns to the identical place. We have found this approach quite useful. In general, the fewer instructions given to the patient the faster and easier the procedure can be performed.

As a corollary to patient positioning, we must also consider the approach used to guide the needle to the nodule. Obviously, we do not position the patient in the prone position if this means we have to traverse the entire thorax to get to an anteriorly situated lesion. Nevertheless, when there is a reasonable choice we generally choose the prone position. Once this choice has been made, there are often obstacles to getting to the nodule; this primarily involves the bony structures. Although on rare occasions we have traversed a bony structure (the sternum) in order to access a nodule, this is almost always unnecessary. In the prone position the scapula is often the most difficult bony structure to navigate around. We have found that the scapula can be rotated out of the way using the following approach: the patient is positioned so that the arm on the ipsilateral side of the nodule is by their side, and is then instructed to rotate the arm externally. This usually moves the scapula out of the way (Fig. 1). If the scapula is still in the way, the patient is rotated so that the side with the nodule is in a less dependent position. A pillow can even be placed under that side so that there is more room for the scapula to move laterally when the arm is externally rotated.

The other bony structures that can often block direct access to the nodule are the ribs. These can also be avoided with relative ease. One approach to avoiding the ribs is to angle the CT gantry. In this way, a plane can be selected that starts above the rib and passes through the nodule without the rib being directly in the plane of scanning. Once this plane is selected the needle can be inserted parallel to this new plane, allowing for direct visualization of the entire needle as it avoids the rib and enters the nodule. A more direct approach than angling the CT gantry is to use basic geometric principles and angle the needle without angling the gantry. In the di-
rect approach, the needle is placed above the obstructing rib and angled inferiorly toward the nodule. Using a series of contiguous axial images it is relatively easy to estimate the needle angle needed and to determine where it will advance on successive images (Fig. 2). In this way, the procedure can be performed with relative ease even for small nodules located close to an obstructing rib. The gantry angulation technique requires a steep angulation to accomplish the same goal.

We have found that in virtually every case we have been able to position the patient in a manner that allows a direct route for needle placement. There is no area of the lung that cannot be approached using TNB. Once the patient is positioned and a route has been selected, needle advancement still requires careful planning. Even slight degrees of malalignment can cause the tip of the needle to miss its target. This is particularly true for small deep lesions. A malalignment of only 3 degrees over a distance of 10 cm deviates from the intended needle course thereby missing a 1-cm nodule. When initially placing the needle through the skin, it is very difficult to assess whether the needle is properly aligned, and perhaps even more difficult to maintain the proper alignment as the needle is advanced. A technique that we have found particularly helpful to compensate for this misalignment has been referred to as bevel steering. This allows for correction of a malpositioned needle tip. The technique relies on the principle that the needle deviates in the direction opposite the bevel. As the needle advances, the surrounding tissue applies a greater force to the beveled surface and deviates the needle tip in the opposite direction. When using this approach, it is sometimes necessary to withdraw and readvance the needle several times to get the desired result. We also make minor adjustments as
Figure 2. Needle angulation to access subcostal lesion. A. Axial scan shows the middle lobe nodule located directly beneath the costal cartilage, precluding a direct perpendicular path within the plane of scanning. B–D, By choosing an entry site above the obstructing costal cartilage and angling inferiorly, the needle is seen to pass sequentially through different contiguous CT slices into the nodule. Note that we generally start above the obstructing rib and angle downward to avoid puncturing intercostal vessels located along the undersurface of the rib.

we are initially advancing the needle. For fluoroscopic biopsies, the position of the needle is checked as it is being advanced and if it is off course, adjustments are made. It is difficult to define exactly how much the needle should be advanced before rechecking its direction, but as a general rule this should be done every 3 to 4 cm.

Now that the needle has reached the desired target and seems to be positioned properly, it is important to document that this is actually true. Because of partial volume averaging on CT, the needle tip can appear to be within the nodule on a single image when it is actually above or below the lesion (Fig. 4). This potential problem can be avoided by the use of contiguous thin sections. These scans should be obtained in a group of three using a slice thickness less than one half the diameter of the nodule, so that the portion of the nodule without the needle tip can be seen above and below the section that actually shows the tip within the nodule. In this way, partial volume effect can be avoided. It cannot be overemphasized that meticulous attention to placing and documenting the needle tip within the nodule is of utmost importance.

The next step in performing the procedure is to obtain the specimen. This requires applying suction to the needle and withdrawing the sample. Although performing this part of the procedure after appropriate needle placement is relatively easy, attention to detail is still important. When a biopsy is performed on small nodules, even minor displacement of the needle can cause the tip to lie outside its intended location. We have found that needles with grid lines on their shaft or with attachable plastic depth markers can be quite helpful in controlling the depth of needle ad-
vancement. The choice of syringe is also important. The syringe must be large enough to achieve maximal vacuum effect while being easy to handle. We have found that this near maximum vacuum effect can be easily achieved with either a 10- or 20-mL syringe. There is no need to use anything larger. The amount of negative pressure does not increase with the larger syringe and, in fact, negative pressure is more difficult to achieve with a larger syringe. Similarly, a syringe of at least 10 mL is needed because often a small amount of air and specimen enter the syringe and enough volume must remain to achieve near maximal negative pressure. With syringes 5 mL or smaller there is a risk of being unable to generate a sufficient vacuum to obtain a diagnostic sample. Careful attention to attaching the syringe to the needle without advancing it requires a consistent approach.

We generally grasp the needle between our thumb and index finger while resting the side of the hand on the patient while the other hand attaches the syringe. After attaching the syringe, suction is applied and fine movements are made to extract the specimen while carefully observing the depth of the needle.

Once the specimen has been obtained it is now up to the cytologist to advise the radiologist as to whether the specimen is adequate. It is quite important to have the cytologist available at the time of the procedure to be able to check for sample adequacy. When a cytologist is not present and the sample has to be transported from the biopsy suite, there can be a significant delay in determining whether sufficient material has been obtained. This may necessitate additional passes or the procedure may need to be terminated without satisfactory results. It is also important to develop a strong working relationship with the cytologist so that one can trust
Figure 4. Partial volume effect and needle tip localization. A, Needle tip seems to be in lingular nodule on axial scan. B, On the next slice, the tip seems to lie outside the nodule. This is caused by a partial volume effect and must be avoided.

their recommendation to obtain additional specimens to make the diagnosis, even when they have reviewed only a portion of the specimen provided. Repeat aspiration is often necessary because at least a portion of the specimen must be kept for permanent and not quick stains.

CYTOLOGIC EVALUATION

As with the biopsy procedure itself, there are several cytologic techniques that help maximize the yield from the specimen provided. The goal of the radiologist performing TNB of pulmonary nodules is to obtain diagnostic samples. These samples are then examined microscopically to detect the presence of a neoplastic or infectious process. Excluding geometric miscalculation, the diagnostic sensitivity and specificity of TNB depends on several factors, including the quality of the specimen preparation and the diagnostic skills of the cytopathologist. The importance of the presence of a cytopathologist during the TNB procedure cannot be understated, because it expedites the procedure and increases the diagnostic yield by decreasing the number of unsatisfactory specimens.

To provide an on-site diagnostic needle biopsy service, we keep a double-headed microscope in the CT suite. A cytology team, consisting of an attending cytopathologist with or without a cytotechnologist, is available on an on-call basis. The team brings a basket of supplies including fixatives and stains needed to prepare the procured specimen. Several different stains are available for the evaluation of TNB material. The two stains we use are the alcohol-fixed Papanicolaou stain and the air-dried Diff-Quik (Dade Behring AG, Dudingen, Switzerland) stain. Although the use of an individual stain is at the discretion of the cytopathologist examining the smears, there are clear advantages and disadvantages to using either alcohol-fixed or
air-dried smear preparations. The alcohol-fixed material stained either with hematoxylin-eosin or the Papanicolaou method results in better preservation of morphologic detail and allows for easier cytologic correlation with the histologic tissue sections. The Papanicolaou stain requires up to 15 minutes and a 24-solution staining procedure. This stain is ideal for the identification of keratinized cells in squamous cell carcinoma. Given the desire for an immediate diagnosis, however, the Diff-Quik stain is ideal for TNB. The Diff-Quik modification of the Wright’s stain technique converts a 4-minute staining procedure into 15 seconds. With this technique, slides are dipped in a methanol-based fixative solution; followed by five dips in solution I (red); five dips in solution II (blue); and then rinsed in water. Because the Papanicolaou and Diff-Quik stains give complementary information, it is recommended that both be prepared from any TNB.

The most important diagnostic decision that the cytopathologist needs to make on-site is whether the specimen is adequate for diagnosis. Specimen adequacy is determined not only by the cellularity but by the adequacy of the cellular preparation for reaching a definitive diagnosis. For example, in the case of a patient with a known primary malignancy and a new lung nodule, a sufficient sampling includes a suspension of cells in CytoLyt solution (Cytyc Corp., Roxborough, MA) for a ThinPrep solution immunocytochemical analysis or a cell block for immunohistochemistry on paraffin-embedded clotted specimens. The ThinPrep sample is prepared by flushing the needle in a CytoLyt fixative container. A fluid sample can be expelled directly in the CytoLyt fixative. Cell blocks can be prepared by expelling a bloody sample onto a watch glass. The clotted specimen can be directly submitted in formalin for histologic preparation.

The false-positive rate of TNB is usually less than 1% in most series.1 Technically, poor preparations account for a majority of these cases. The interpretation of smears may be limited by obscuring blood or inflammation or by smearing and air-drying artifacts. In rare instances, epithelioid histiocytes or reactive bronchioloalveolar cells have been misdiagnosed as adenocarcinoma because of artifacts induced by fixation and preparation. We prefer to have the radiologist (the aspirator) transfer the syringe with the attached needle directly to the cytopathologist. The cytopathologist then makes several air-dried smears for immediate evaluation and several smears are placed in alcohol for a Papanicolaou stain. The needle is then rinsed in CytoLyt solution.

Based on the air-dried smears, a decision is made by the cytopathologist about additional passes. If a malignant diagnosis is made, additional passes may still be necessary for ancillary studies. If necrotic material is obtained, the cytopathologist must ensure that sufficient material is available for acid-fast and fungal stains and cultures. The air-dried smears must be scrutinized for both organisms and malignant cells. The sensitivity of the TNB cytology sample is often diminished when the cellular sample is not spread evenly on slides or not preserved by rapid and complete fixation. As an alternative, if a cytopathologist is unavailable, sample expulsion directly into CytoLyt solution ensures optimal cell preservation and maximum cell capture by the laboratory. The CytoLyt solution hemolyses blood and dissolves mucus. In a review of our work (personal data), 50 (92.5%) of 54 ThinPrep slides prepared from CytoLyt-preserved TNB specimens were diagnostic, with 39 (78%) positive for malignancy. All positive cases were diagnosed by one pathologist and two cytotechnologists with 100% concordance. The primary site of malignancy was determined in 9 (69%) of 13 patients with an unknown primary by immunostaining of additional ThinPrep slides using the same CytoLyt-preserved specimen.

The cytopathologist must always be aware that complications are minimized by reducing the length of the procedure. Occasionally, very bloody samples are obtained that require a multitude of slides if smeared directly, making the procedure lengthy. When a bloody aspirate is obtained, we prepare a concentrated cell block for immunohistochemistry while providing a quick and accurate on-site diagnosis. Bloody aspirates are expressed onto a rim of a watch glass. We then apply a technique referred to as pick and smear that concentrates the tissue fragments. This is performed by layering the aspirate along the convex border of the watch glass and gathering visible tissue fragments along the rim with a 1.5-inch, 25-gauge needle. Smears are then made from the tissue fragments and a Diff-Quik stain performed to confirm a positive result. The remaining fragments are gathered into a collection that is allowed to clot. Standard immunohistochemical panels are performed on the cell block. In a review of our work (personal data) we were able to apply successfully a standard panel of immunohistochemical stains on 75 consecutive
cases in which bloody aspirates were obtained and in which fragments could be identified in this manner. The average number of passes required was 1.2. The average number of slides examined on-site was four. The most useful immunohistochemical panel included cytokeratin 7 (CK7) and cytokeratin 20 (CK20), which allowed for the differentiation of primary lung adenocarcinoma (CK7 positive, CK20 negative) from adenocarcinoma of colonic origin (CK7 negative, CK20 positive) in 14 cases (Fig. 5). In 12 patients with breast cancer, a panel including estrogen and progesterone receptors and Her-2/neu provided definitive diagnosis and information affecting therapy. Additionally, the unfixed aspiration biopsy specimen can be analyzed by flow cytometry to determine the DNA index of neoplasms.

In our experience, if a diagnosis of malignant lymphoma is suspected, a core biopsy should be obtained. In general, an insufficient number of cells is obtained by needle aspiration biopsy to perform the necessary lymphoid marker studies. Additionally, core biopsies allow for the evaluation of the histology of the malignant lymphoma that is necessary for the subclassification of the malignant lymphoma as nodular or diffuse. The specimen should be submitted in saline or RPMI (Life Technologies, Baltimore, MD) medium. A touch preparation of the core biopsy is stained with the Diff-Quik stain for immediate diagnosis by the cytopathologist. This is to ensure that the core biopsy material consists of a lymphoproliferative process rather than associated inflammation or fibrosis.

In some instances, we believe that adequate evaluation of lymphoproliferative disorders can be made by aspiration biopsy alone. Unfixed samples of aspirated material can be submitted for flow cytometry, immunohistochemistry, and cytogenetics. Monoclonality can be demonstrated rapidly by flow cytometry by showing a restricted expression of a single surface immunoglobulin light chain in the neoplastic cell population. A limited panel of antibodies including CD5 and CD10 can give confirmatory evidence of recurrence in a patient who has a history of malignant lymphoma. For example, the most common non-Hodgkin's lymphomas are B-cell lymphomas, which can be divided into prefollicular center cell types (CD5 positive, CD10 negative); follicular center cell types (CD5 negative, CD10 positive); and postfollicular center cell types (CD5 negative, CD10 negative). If necessary an unfixed sample may be sent for cytogenetic analysis to look for chromosome translocations that have been identified in non-Hodgkin's lymphoma, mostly involving sites of immunoglobulin heavy and light chain genes on chromosomes 2, 14, and 22.

In summary, a cellular or necrotic specimen obtained by TNB should be smeared for Diff-Quik (air-dried) and Papanicolaou (alcohol-fixed) staining methods. The needle should be rinsed in CytoLyt solution. When a bloody specimen is obtained, tissue fragments are smeared from the bloody material expelled onto a watch glass. The clotted specimen is then fixed in formalin for a cell block preparation. The TNB procedure is repeated based on the immediate impression by the cytopathologist. If a diagnosis of malignant lymphoma is suspected, a core biopsy and touch preparation are recommended.

**COMPLICATIONS**

Once the procedure has been performed and the specimen obtained, our remaining goal is to minimize complications. To accomplish this final goal effectively, potential complications should be considered before the procedure. The two most common complications of TNB are hemorrhage and pneumothorax. We focus on methods to reduce pneumothorax, because bleeding is primarily related to factors intrinsic to the patient or because of medications.

The rate of pneumothorax has been variously reported to range from as low as 5% to 10% to as high as over 60%. There are several reasons for this wide range of values. Several factors have been implicated including the type of needle used, the number of passes made, the location of lesions, the degree of emphysema in the lung parenchyma that must be traversed to reach the lesion, and the time it takes to perform the procedure. Additionally, postbiopsy maneuvers (which are discussed later) have also been reported to reduce the incidence of pneumothorax. A less apparent but perhaps most important cause for the wide variation in the reported rate of TNB-induced pneumothorax is the threshold for what is considered a pneumothorax. With CT scanning, it is now possible to see very small pneumothoraces that are not seen on chest radiography. A small pneumothorax may be identified on CT immedi-
Figure 5. Distinction of primary from metastatic adenocarcinoma by immunostaining. A, An aspirate of solitary pulmonary nodule in a patient with colon cancer showed monolayered sheets and clusters of epithelial cells with bland nuclei and columnar cytoplasm in a background devoid of necrosis. B, An immunostain for cytokeratin 7 (CK7) on a Thin-Prep specimen shows strong cytoplasmic staining. An immunostain for cytokeratin 20 (CK20) was negative. The immunohistochemical panel is consistent with a lung primary (CK7+, CK20−) and excludes metastatic colon carcinoma (CK7−, CK20+).
ately postbiopsy yet be invisible on a follow-up chest radiograph obtained 2 hours later. Similarly, a tiny (less than 1%) pneumothorax that can often be detected with CT may barely warrant mention. The reported pneumothorax rate depends on how these small pneumothoraces are counted.

Each of the factors implicated in producing pneumothorax deserves some consideration. In general, there is not much to be done about the status of the underlying lung parenchyma. It may be possible, however, to choose a path for needle placement that minimizes the amount of diseased lung that must be traversed. When possible, placing the needle through large bullae should be avoided (Fig. 6). Similarly, a path that avoids crossing fissures can often be chosen because the risk of pneumothorax significantly increases if an interlobar fissure is traversed. The time needed to perform the procedure must also be minimized. This is best accomplished by positioning the patient for the procedure in a comfortable position thereby avoiding patient movement. The time needed to perform the biopsy also decreases as the operator gains experience. As stated previously, an experienced on-site cytologist can help decrease the number of passes necessary by rapidly determining when sufficient material has been obtained. Needle choice is often a matter of personal preference. When trying to confirm a benign diagnosis, it is often necessary to use larger-gauge needles to obtain specific

Figure 6. Transthoracic needle biopsy in a patient with emphysema. A, A patient with a new solitary lung nodule shows extensive bullous emphysema surrounding the lesion. B, By careful selection of a needle route by a posterior approach that allowed needle placement through areas of near normal lung parenchyma that avoided bullae, the biopsy was accomplished and a pneumothorax avoided.
benign results. In those cases where malignancy is suspected, a smaller-gauge needle is probably more appropriate because only a small amount of material is necessary to make a confident diagnosis.³

Even more important than pneumothorax rate is the rate of chest tube insertion following TNB, which is generally reported as 5% to 10%. Chest tube insertion is necessary when the pneumothorax has enlarged to the point where the patient requires treatment. It is generally accepted that a pneumothorax exceeding 30%, even in an asymptomatic patient, requires chest tube placement. It should be noted that the decision to drain a biopsy-induced pneumothorax must be determined on an individual basis. Because patients tolerate pneumothorax differently depending on underlying lung function, a pneumothorax smaller than 30% may also require chest tube placement. An approach to pneumothorax management that avoids chest tube placement that we have advocated is pneumothorax aspiration.⁹ The concept is relatively simple. A small-gauge catheter, usually a 2-in, 18-gauge angiocatheter used for routine intravenous access, is placed directly into the pleural space and the air is evacuated. We accomplish this by attaching the angiocatheter to intravenous extension tubing attached to a three-way stopcock and 50-mL syringe. The pneumothorax is evacuated by alternately opening and closing the stopcock to allow air to be withdrawn from the pleural space and then expelled into the room. A one-way valve, such as that used in pleural effusion drainage, can also be used. The pneumothorax is evacuated until resistance is felt during manual suction, which occurs when a sufficient amount of lung re-expansion has brought the visceral pleural surface of the lung in contact with the tip of the angiocatheter. At this point, the tip of the angiocatheter is slightly withdrawn and suction reapplied. In this way the pneumothorax can be completely evacuated (Fig. 7). As a supplement to manual aspiration of the pneumothorax, the patient is placed on oxygen. The high oxygen concentration promotes more rapid resorption of the pneumothorax should it re-accumulate.

Once an additional CT image has documented successful evacuation of the pneumothorax, the patient is placed in the biopsy-site–dependent position. Dependent positioning allows the pleural surfaces to appose, helping seal the leak and minimizing alveolar volume in the dependent lung. The patient is required to remain in the biopsy-site–dependent position for 2 hours, and serial chest films are obtained. If the patient remains comfortable, the first film is obtained at 2 hours postprocedure. If there is no pneumothorax, the patient can be discharged, whereas an additional film is obtained in 2 hours if the pneumothorax has partly reaccumulated. If at this point the pneumothorax is stable, the patient is discharged, whereas a chest tube is inserted if it has enlarged. Although this technique has not completely eliminated the need for chest tube placement, it has significantly reduced its incidence. We are nearly always initially successful in completely aspirating the pneumothorax, although it does reaccumulate in approximately 40% to 50% of patients. Of those patients whose pneumothoraces reaccumulate, the pneumothorax is often smaller than the initial size and the patient can often be discharged without tube drainage.

Another situation where the aspiration technique has been useful is when a pneumothorax develops during the course of the biopsy and an additional needle pass is necessary. In the presence of a pneumothorax, the entire lung is more mobile and the more mobile and less stretched pleura is difficult to puncture. These factors combine to make accurate needle placement much more difficult. It is also much more difficult to reposition a misdirected needle in the presence of a pneumothorax. In this circumstance, we find it useful to evacuate a small pneumothorax normally not large enough to warrant drainage. When draining a pneumothorax that precedes successful completion of the biopsy, the angiocatheter is left within the pleural space and attached to a Heimlich valve. Once the biopsy has been completed, the angiocatheter is removed and the patient placed in the biopsy-site–dependent position. We have also had success draining pneumothoraces using one-piece small-gauge chest tubes with self-contained one-way valves.

Another technique that has been used with variable success to reduce pneumothorax and chest tube rate following TNB is a blood patch.² With this technique, a small amount of the patient's clotted blood is injected at the end of the biopsy procedure as the outer cannula of the indwelling coaxial needle is withdrawn. The basic principle for this approach is quite sound, because the clotted blood serves to seal the tract created by the biopsy needle and thereby reduce the likeli-
Figure 7. Aspiration of biopsy-induced pneumothorax. A, A large pneumothorax is noted following right lung biopsy. B, An angiocatheter is seen in the pleural space during manual aspiration of the pneumothorax. C, Following aspiration, the pneumothorax was evacuated completely and did not reaccumulate.
hood of air leakage. Alternatively, other investigators have recommended injecting gel-foam to seal the biopsy track. Although we do not use the blood patch technique at our institution, in part because we do not use a coaxial needle technique, we have noted a smaller tendency for patients to develop pneumothoraces when a small amount of bleeding is identified along the needle track on a postbiopsy CT scan.

SUMMARY

We believe that each aspect of the performance of TNB needs to be considered carefully. Meticulous attention to detail allows any nodule in the chest to successfully undergo biopsy. There are techniques of needle tip repositioning that can be quite helpful for obtaining diagnostic material from lung lesions, particularly small nodules. A strong working relationship with pathologists experienced in lung cytology is a vital element of any successful biopsy program. Techniques available to the pathologist allow for quick and decisive determination of the adequacy of the aspirated specimen and help guide the radiologist performing the procedure. Newer cytopathologic techniques help the pathologist make more complex diagnoses from the aspirated material. Finally, techniques used to minimize complications should be considered by the operator before the performance of the biopsy.

References


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