Procedures in Family Practice

Tube Thoracostomy

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Every primary care physician should be familiar with three methods of draining fluid or air from the pleural cavity. These methods are: (1) the insertion of a needle or Intracath catheter into the pleural space; (2) a tube thoracostomy using a Trocar catheter; and (3) a tube thoracostomy using a large intercostal tube. Complete anesthesia can be obtained with lidocaine, remembering that the intercostal nerve runs on the undersurface of the rib above. The Intracath catheter for removal of air is inserted in the second interspace anteriorally. The tube thoracostomy, using the Trocar catheter, is best done through the fourth interspace in the anterior axillary line but can be done wherever the exploratory needle shows the major fluid and air collection to be. The tube thoracostomy, using a large intercostal tube, is best done through the fourth intercostal space at the anterior axillary line. The intercostal catheter or tube should be fixed to the chest wall with sutures and then led to an underwater seal for collection of the contents of the pleural cavity.

There are essentially three types of chest tubes that every physician may be called upon to insert. These are: (1) the small, flexible polyethylene catheter, no larger than an 18 gauge needle; (2) the Trocar catheter, a plastic catheter ranging in size from 4 to 20 mm, equipped with an indwelling pointed rod for simplicity of insertion; and (3) the standard large bore, intercostal, plastic chest tube, ranging in size from 12 to 40 mm in diameter. The purpose of this communication is to describe the method of insertion of each of these chest tubes, and to clarify the potential uses and advantage of each type of chest catheter.

Indications for Insertion of Chest Tubes

A chest tube is inserted into the thoracic cavity for the removal of air, blood, or abnormal fluid collections in the chest.

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Air in the chest most commonly comes from the spontaneous pneumothorax, wherein a bleb on the surface of the lung breaks, air leaks into the chest, and the lung collapses. It could also follow a laceration of the lung from a fracture of the ribs. More severe violence may even rupture a bronchus, or the lung itself, liberating large amounts of air into the pleural cavity. The buildup of air in the pleural space results in loss of the normal negative pressure within the chest, and if air continues to leak into the closed pleural space, a positive pressure develops in the pleural space. If this becomes large enough, it not only compresses the lung on the side of the leak, but pushes the mediastinum over and embarrasses ventilation of the opposite lung, thereby resulting in a *tension pneumothorax*. If the air remains within the closed pleural space, one can only detect it by physical examination of the chest, or by radiological examination of the chest. If the pleura or mediastinal pleura is broken, air may leak out into the subcutaneous tissue of the chest wall, or of the neck, and one can feel subcutaneous air either in the

chest wall, neck, or mediastinum in relationship with the pneumothorax.

Most spontaneous pneumothoraces result in rapid collapse of the lung with sealing of the leak, so that a progressive tension pneumothorax does not develop, but dyspnea commonly results from the collapse of the lung, particularly in the elderly patient, or in one with embarrassed respiratory motion from old poliomyelitis. A large leak results in a tension pneumothorax, and a large leak with rupture of the pleurae or mediastinal pleura results in subcutaneous emphysema in addition to the pneumothorax.

Blood in the pleural cavity commonly results from broken ribs or from a small superficial laceration on the surface of the lung. The blood within the pleural cavity generally does not clot unless there is a great deal of associated trauma connected with its liberation, or unless external air or tubes are introduced into the chest. Blood is also fairly rapidly absorbed from the pleural cavity, provided it remains liquid. Not every hemothorax, therefore, needs to be tapped or treated by the insertion of a chest tube, but an expanding hemothorax demonstrated on serial chest x-rays should be tapped when it reaches the size sufficient to embarrass normal respiratory function. A hemothorax or pneumothorax rendering the patient short of breath should be tapped and drained to the outside. It will require a larger tube to drain blood from the pleural cavity than to remove air. Clotted blood within the pleural cavity will require a larger tube for drainage than would liquid blood.

Abnormal fluid within the pleural cavity arises from an inflammatory or neoplastic process on the surface of the lung or on the pleura. A thin watery secretion can be drained through a relatively small tube. A purulent coagulated effusion will require a large tube for effective drainage. Small effusions need not be drained, unless one wishes to tap them for diagnostic purposes. Large effusions which embarrass respiration and recur are best tapped. An effusion accompanied by fever must be tapped for diagnostic purposes. A bloody effusion is more often neoplastic in origin than inflammatory in origin. The emphasis now in all pleural effusions is to obtain rapid and complete expansion of the lungs, thereby preserving pulmonary function. Purulent effusions must then be drained promptly and completely through a large bore tube. Bloody effusions of neoplastic origin tend to recur and are best treated by inserting a fairly good-sized intercostal tube, draining off all of the fluid with complete expansion of the lung, and then sealing the parietal to visceral pleura by the insertion of an irritant, such as nitrogen mustard or Atabrine, through the intercostal tube prior to its removal, once the lung has been fully expanded.

It is invariably my practice, prior to insertion of a chest tube, to determine the nature of the effusion by carrying out a *diagnostic pleural tap* with appropriate cultures, smears, and cytological studies of the pleural fluid. *The chest tube is ordinarily not inserted until the cause of the effusion has been clarified, and the importance of appropriate treatment ascertained.*

Methods of Insertion of Chest Tubes

The Small Polyethylene Catheter

The simplest way to insert a small polyethylene catheter into the chest for removal of modest amounts of air with a minimal air leak from the lung is by the use of a Deseret needle or similar type needle. These are needles of either the 14 or 16 bore caliber, through which a small polyethylene catheter can be inserted. They now come made up in the forms of the Intracath, and are commonly used for insertion of small polyethylene catheters into the subclavian vein. The same Deseret intracath or similar type of polyethylene tube with an accompanying needle can be used in the chest.

Complete anesthesia with local anesthetic agents is mandatory. No pain at all should be incurred in the insertion of a needle or tube within the thoracic cavity. One percent lidocaine without adrenaline is used. The best site for insertion of the small polyethylene catheter for the removal of air is the second anterior intercostal space at the level of the midclavicular line (Figure 1). A skin wheal is produced by intradermal injection of one percent lidocaine, using a short bevel 25 gauge needle. This is practically painless. A 1 1/2 to 2 inch 22 gauge needle is then used to infiltrate the subcutaneous tissue and intercostal muscles. Remember that the intercostal nerve and artery run along the lower surface of the rib above (Figure 2). One must completely infiltrate the subcutane-

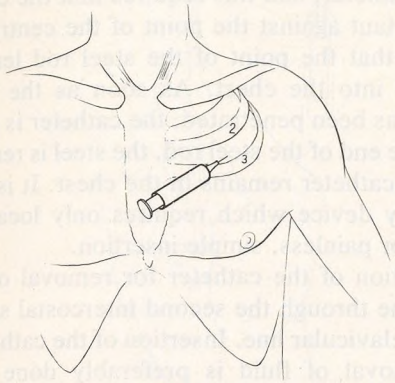

Figure 1. Insertion of lidocaine anteriorally between the second and third interspace. This illustrates the intracutaneous injection with a small needle.

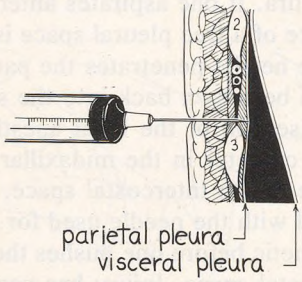

Figure 2. Insertion of a larger 22 gauge intramuscular needle through the subcutaneous tissue over the top of the underlying rib down to the pleura with anesthetization of these structures as one goes along.

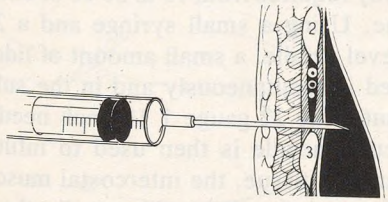

Figure 3. Use of an 18 gauge needle to puncture the pleura and establish the presence of blood or air in the pleural space.

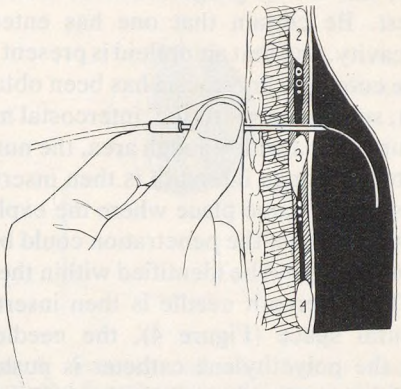

Figure 4. Insertion of the Intracath catheter into the pleural space for the removal of air from the pleural cavity.

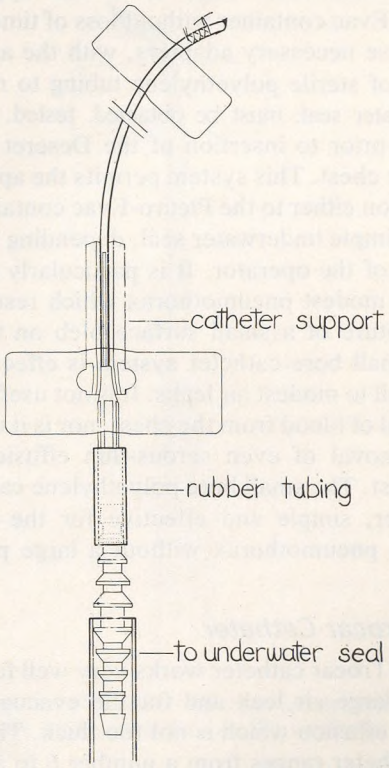

Figure 5. Method of attachment of the Intracath catheter with support from the needle-guard, and the appropriate connectors leading to the underwater seal.

ous tissue and intercostal muscles down to the parietal pleura. The parietal pleura is then anesthetized, and the 22 gauge needle is inserted into the chest. Be certain that one has entered the pleural cavity, and that air or fluid is present (Figure 3). Once complete anesthesia has been obtained of the skin, subcutaneous tissue, intercostal muscles, and pleura over a wide enough area, the number 16 or number 18 gauge intercath is then inserted into the chest in the same place where the exploratory needle showed that the penetration could be safely made, and air could be identified within the pleural space. The intercath needle is then inserted into the pleural space (Figure 4), the needle is removed, the polyethylene catheter is pushed several inches into the chest. It is then affixed to the skin so that it will not be pushed out as the patient moves and as the lung expands. It is important that one have available appropriate adapters, so that one can run from the hub of the polyethylene tube to an underwater seal, or to the appropriate Pleuro-Evac container without loss of time (Figure 5). These necessary adapters, with the additional length of sterile polyethylene tubing to reach the underwater seal, must be obtained, tested, and connected prior to insertion of the Deseret catheter into the chest. This system permits the application of suction either to the Pleuro-Evac container or to just a simple underwater seal, depending upon the wishes of the operator. It is particularly effective for the modest pneumothorax which results from the rupture of a small surface bleb on the lung. This small bore catheter system is effective only for small to modest air leaks. It is not useful for the removal of blood from the chest, nor is it useful for the removal of even serous-thin effusions from the chest. The small bore polyethylene catheter is, however, simple and effective for the small or modest pneumothorax without a large persistent leak.

The Trocar Catheter

The Trocar catheter works very well for a modest to large air leak and for the evacuation of a serous effusion which is not too thick. The size of the catheter ranges from a number 6 to a number 16 or 18 gauge. The Trocar catheter is a siliconed plastic tube with a central steel rod that is pointed on one end and is equipped with a plastic ball handle on the other end. The ball handle can be used for inserting the pointed steel rod together with the catheter into the chest (Figure 6). Only a small portion of the point sticks out beyond the tip of the catheter, and this requires that the catheter be held taut against the point of the central steel rod, so that the point of the steel rod leads the catheter into the chest. As soon as the pleural cavity has been penetrated, the catheter is pushed off of the end of the steel rod, the steel is removed, and the catheter remains in the chest. It is a simple, easy device which requires only local anesthesia for painless, simple insertion.

Insertion of the catheter for removal of air is best done through the second intercostal space in the midclavicular line. Insertion of the catheter for the removal of fluid is preferably done in the midaxillary line at the level of the fourth intercostal space (Figure 7). Invariably before the catheter is inserted, the operator must be certain that he/she is entering the pleural space; this is done by aspirating with the 22 gauge intramuscular needle, which is used to insert the local anesthetic deeply into the intercostal muscles and on the parietal pleura. If one aspirates anteriorly for air, the presence of a free pleural space is detected as soon as the needle penetrates the parietal pleura, and air can be drawn back into the small syringe used for insertion of the local anesthetic. If one inserts the catheter in the midaxillary line at the level of the fourth intercostal space, fluid should be obtained with the needle used for inserting the local anesthetic before one pushes the Trocar into this intercostal space. Injury has occurred by inserting the catheter below the diaphragm unwittingly, and I invariably test for the presence of fluid or air with the needle used for local anesthesia before inserting the larger catheter.

Enough local anesthesia must be used in the skin, subcutaneous tissue, intercostal muscle, and pleura to make the procedure really painless. This commonly requires from 15 to 30 cc of one percent lidocaine. Using a small syringe and a 25 gauge short bevel needle, a small amount of lidocaine is deposited intracutaneously and in the subcutaneous tissue. The 22 gauge 1 1/2 inch needle or intramuscular needle is then used to infiltrate the subcutaneous tissue, the intercostal muscles, and the parietal pleura. With this needle the parietal pleura is punctured and either air or fluid is drawn back into the syringe to be certain that a free pleural space has been entered prior to insertion of the catheter. Once the free nature of the pleural

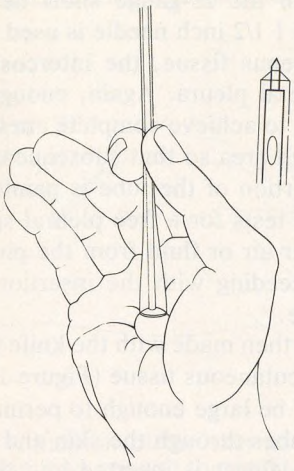

Figure 6. The method of holding the Trocar catheter in the palm of the hand so that the catheter is pulled flush against the palm of the hand permitting the point of the Trocar to extrude beyond the catheter so that insertion into the chest is accomplished by the pointed end of the Trocar.

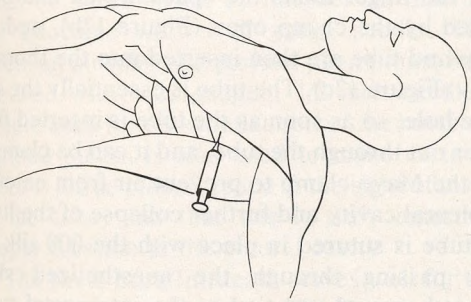

Figure 7. Anesthetization of the intercostal space at the level of the fourth intercostal space along the anterior axillary line.

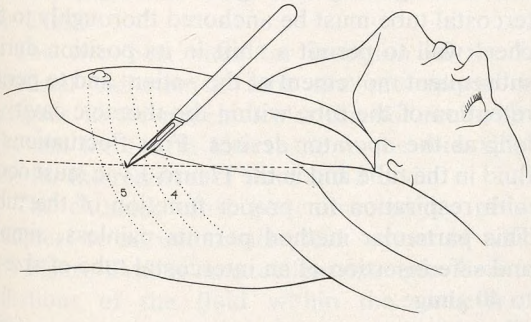

Figure 8. A small incision is made parallel to the skin crease between the fourth and fifth ribs for the insertion of the Trocar catheter.

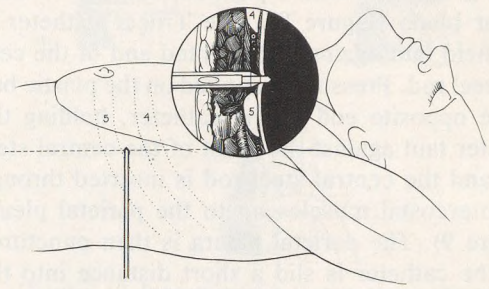

Figure 9. Insertion of the Trocar catheter through the fourth intercostal space. Note that the hand pulls the catheter against the palm of the hand permitting the point of the Trocar to lead the way through the intercostal muscles.

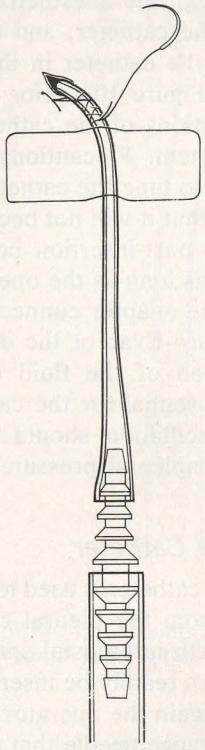

Figure 10. Fixation of the intercostal catheter and connection to the underwater seal.

In all of these illustrations the patient is lying on the back and appropriate exposure is obtained by elevation of the arm. The anterior axillary line is viewed from the side but the patient is lying on the back.

space has been ascertained, a small incision large enough to readily admit the diameter of the catheter through the skin and subcutaneous tissue is made in the skin with a pointed, number 11 Bard Parker blade (Figure 8). The Trocar catheter is then held taut against the pointed end of the central steel rod. Pressure is applied on the plastic ball at the opposite end of the catheter, holding the catheter taut against the point of the central steel rod, and the central steel rod is inserted through the intercostal muscles up to the parietal pleura (Figure 9). The parietal pleura is then punctured and the catheter is slid a short distance into the pleural cavity. The rod is then removed from the catheter, the catheter is quickly clamped to prevent ingress and egress of air from the catheter, and the catheter is then inserted into the chest to any desired distance. A 000 or 00 silk suture is then passed through the anesthetized skin at the site of entry of the catheter, and this is used to anchor and hold the catheter in the chest at the proper location (Figure 10), prior to making the necessary connections of the catheter to the underwater seal system. Precautions must also be taken, of course, to tape the catheter properly on the chest wall so that it will not become dislodged in the immediate post-insertion period, and will stay in the chest as long as the operator desires.

The appropriate adapter connects the catheter to either the Pleuro-Evac or the underwater seal system. Oscillation of the fluid column in the Pleuro-Evac is essential for the catheter to work properly. The oscillation should demonstrate a fluctuation in intrapleural pressure as the patient breathes.

The Large Bore Catheter

The large bore catheter is used to drain blood or thick effusions from the pleural cavity. It is inserted in the fourth intercostal space in the midaxillary line. It can readily be inserted under local anesthesia, and again the operator should be certain with the 22 gauge needle that is used to infiltrate the intercostal muscles and parietal pleura that a free pleural space exists at the point at which the intercostal tube is to be inserted. This simple test with the anesthetizing and aspirating needle ensures against injury to the diaphragm, liver, or spleen depending upon the site of insertion of the intercostal tube.

The skin is again anesthetized with one percent lidocaine with the 25-gauge short bevel needle. The 22 gauge 1 1/2 inch needle is used to infiltrate the subcutaneous tissue, the intercostal muscle, and the parietal pleura. Again, enough lidocaine must be used to achieve complete anesthesia over a wide enough area so that subsequent manipulation and insertion of the tube is painless. The 22 gauge needle tests for a free pleural space by aspirating either air or fluid from the pleural cavity prior to proceeding with the insertion of the intercostal tube.

Incision is then made with the knife through the skin and subcutaneous tissue (Figure 11). This incision should be large enough to permit easy passage of the tubes through the skin and subcutaneous tissue. A finger is inserted into the incision, the intercostal space is palpated, and a clamp of the Mayo type or of the more pointed Kelly type is inserted through the intercostal muscles into the chest (Figure 12a). It is then spread large enough so that the tube can be inserted through the hole which is kept open with the exploring finger. The clamp is removed, is used to grasp the intercostal tube, the finger holds the space which had been created by the clamp open (Figure 12b), and the clamp and tube are then inserted into the thoracic cavity (Figure 12c). The tube is essentially the size of the hole, so as soon as the tube is inserted fluid rushes out through the tube, and it can be clamped with the Mayo clamp to prevent air from entering the pleural cavity and further collapse of the lung. The tube is sutured in place with the 000 silk sutures passing through the anesthetized skin, wrapped around and tied to the intercostal tube. Appropriate connections are then made to the Pleuro-Evac, the clamp is removed from the tube, and drainage begins (Figure 13). Again, the intercostal tube must be anchored thoroughly to the chest wall to permit a shift in its position during subsequent movement of the patient and to permit retention of the tube within the thoracic cavity as long as the operator desires. Free fluctuations of fluid in the tube and in the Pleuro-Evac must occur with respiration for proper function of the tube. This particular method permits painless, simple, and safe insertion of an intercostal tube of size 14 to 40 gauge.

Summary

Intercostal drainage of fluid or air can readily be established from the pleural space by the use of

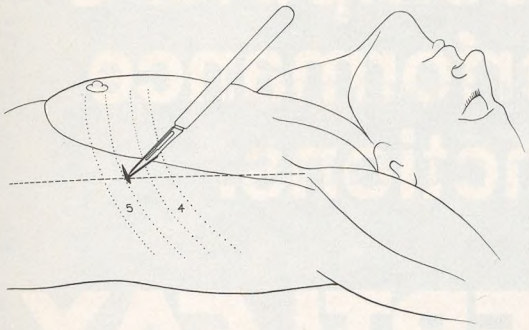

Figure 11. Incision of the skin parallel to the skin crease long enough to permit insertion of the larger tube into the chest cavity.

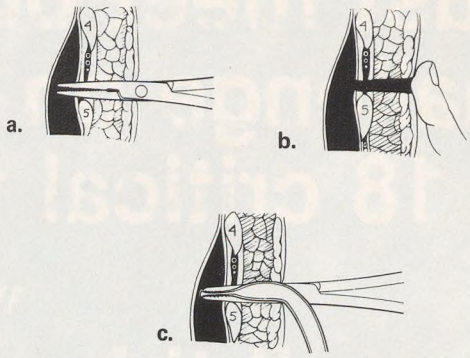

Figure 12. Insertion of a clamp along the top of the rib below (12a), holding the hole in the pleural space closed with the finger (12b) until the chest tube is inserted in the pleural space (12c).

either a small polyethylene catheter (the Intracath), the use of a Trocar catheter, or the use of a standard intercostal tube. Local anesthesia makes this procedure simple and completely painless. For it to be completely painless, the skin must be anesthetized by intradermal insertion of the lidocaine with a 25 gauge needle. The intercostal muscles and parietal pleura must be anesthetized with a 22 gauge 1 1/2 inch needle. The needle used for anesthetization of the muscles and parietal pleura is also used to make certain that there is a free pleural space at the sight of insertion of the tube, and that one is truly entering the proper location in the pleural cavity.

The small bore Intracath serves well for the removal of minimal air leaks. The Trocar catheter is effective for tension pneumothorax and thin, serous effusions. The large bore catheter is necessary for the removal of blood and thick effusions from the chest.

The two best sites for insertion of the intercostal catheter or tube are the second interspace in the midclavicular line for removal of air, and the fourth interspace in the midaxillary line for the removal of fluid and blood.

The catheter must be connected by proper adapters to an underwater seal system of which the Pleuro-Evac is an excellent example. Free oscillations of the fluid within the catheter or Pleuro-Evac system must occur on breathing. The catheter is properly anchored with skin sutures and tape to prevent inadvertent slippage from the thoracic cavity.

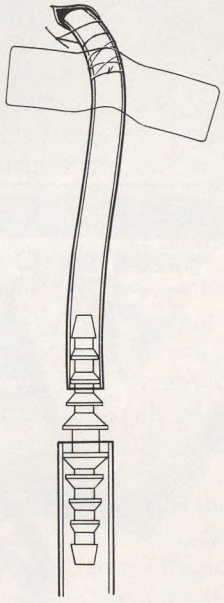

Figure 13. Connection of the intercostal tube to the underwater seal.

In all of these illustrations the patient is lying on the back and appropriate exposure is obtained by elevation of the arm. The anterior axillary line is viewed from the side but the patient is lying on the back.