I certainly hope the description of these various surgical techniques will be of benefit to the practicing general thoracic surgeon.

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THORACIC INCISIONS

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For many years, there were basically two common means for the surgeon to enter the chest: (1) posterolateral thoracotomy and (2) median sternotomy. There were, of course, other incisions, but only in recent years has there been a general renewed interest in them—often involving a rediscovery of incisions used by our "surgical grandparents." The refinement of single lung anesthesia and the perfection of our surgical instrumentation have enabled us to perform more procedures through smaller incisions. The rapid international development of video-assisted thoracic surgery (VATS) has increased the emphasis on and use of alternative incisions. This article addresses some of the pros and cons of the traditional incisions and discusses some of the various alternative incisions.

POSTEROLATERAL THORACOTOMY

The posterolateral thoracotomy remains the "gold standard" for exposure for most general thoracic surgical procedures and by international consensus, it is the thoracic incision associated with the most postoperative pain. Many descriptions of the incision are readily available.[4] Our preference, at the outset, is to ask our anesthesia colleagues to place a thoracic epidural catheter prior to the induction of general anesthesia, and we prefer generally a double lumen endotracheal tube. Our three indications for using a posterolateral incision are: a previous thoracotomy; an anticipated different procedure such as a sleeve lobectomy; and an anticipated pleural symphysis. A single dose of intravenous antibiotics, usually a cephalosporin, is given prior to making the

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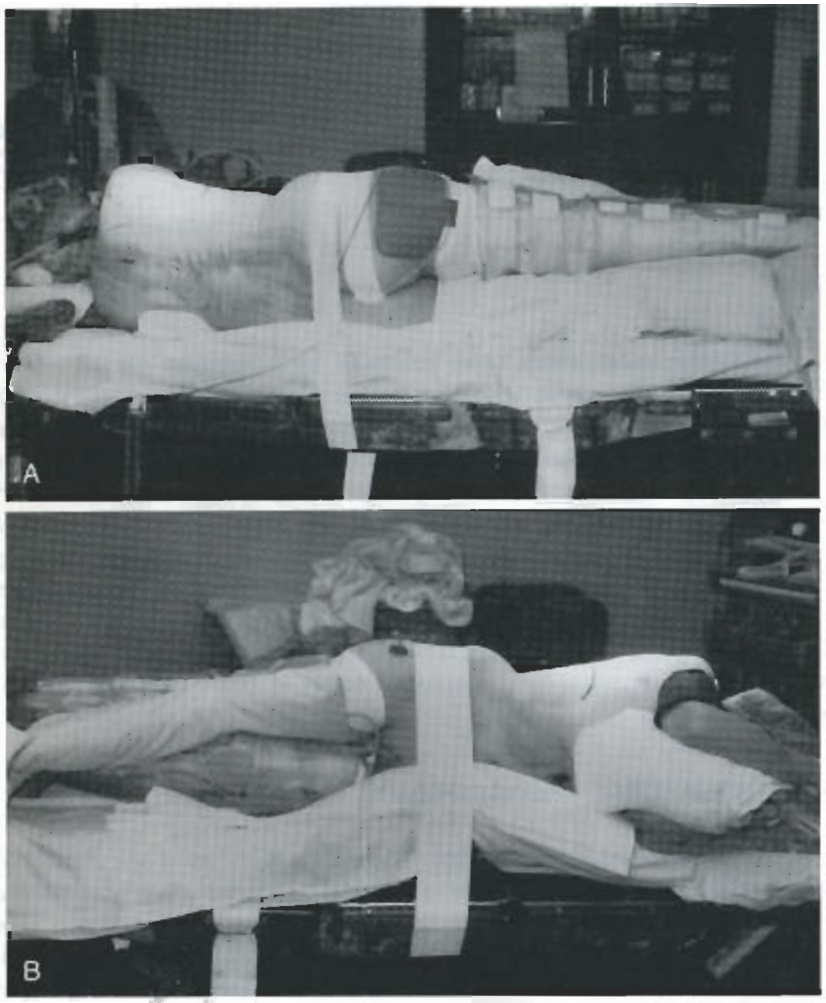

Figure 1. Posterolateral thoracotomy. *A*, Posterior view. Note the axillary roll, the elastic stockings, and the sequential compression device. The legs are padded with foam at the dependent parts and with pillows between. An epidural catheter is in place. *B*, Anterior view. Note the arms in "praying position" with padding between the elbows and foam padding under the knee.

Illustration continued on opposite page

skin incision, and additional dosages of antibiotics are given generally only if there has been a prolonged, open aerodigestive procedure, such as a sleeve lobectomy or an esophagogastric anastomosis.[11] Those thoracotomy patients having risk factors for deep vein thrombosis receive prophylaxis, consisting of elastic hose and a sequential compression device (SCD) with the hose in place preoperatively, and the SCD functioning at the time of anesthetic induction. The positioning of the patient

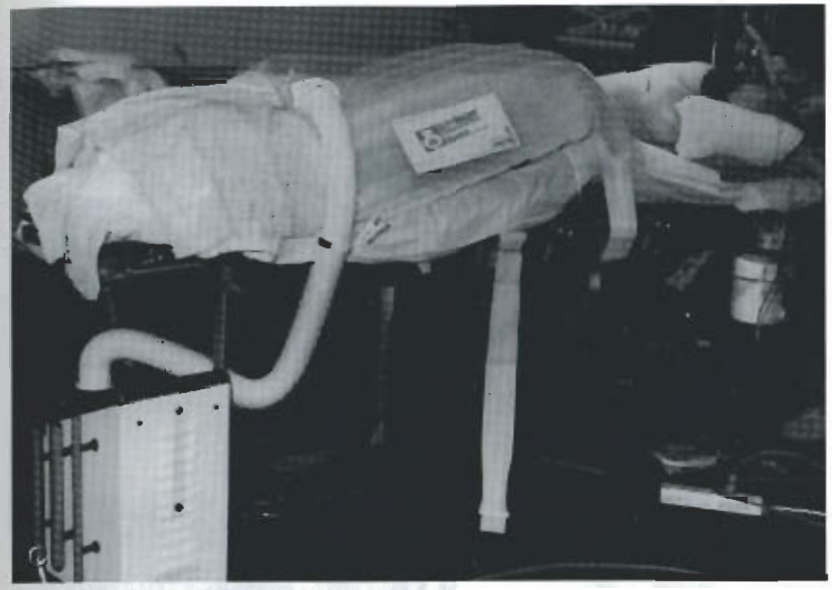

Figure 1 *(Continued). C*, A warming device in place that is desirable for long procedures when cooling of the patient can be deleterious.

is important (Fig. 1), and we stress the importance of an axillary roll to reduce pressure on the brachial plexus; proper padding under pressure points such as the down elbow, knee, and ankle; and adequate padding between the legs—the bottom leg is bent with the top leg positioned straight to help maintain position. We prefer to position the arms in the "praying position" though some surgeons prefer positioning the up arm on a pillow, resting on a Mayo stand. We prefer a fifth interspace incision (S-shaped) for upper lobe procedures or pneumonectomy, a sixth interspace incision (a gentle curve) for middle and lower lobectomies, and a seventh interspace incision (an oblique line) for procedures about the diaphragm and esophageal hiatus. We reserve full rib resection for repeat thoracotomies for facilitation of entry into a potentially obliterated pleural space; we prefer to shingle one or both ribs at the costovertebral angle in patients over 40 years of age. The electrosurgical unit is used both for hemostasis and for musculofascial dissection. A Finochietto retractor is placed posterior and a Tuffier retractor anterior, thus, obtaining good exposure of the operative field.

For closure, we prefer that two chest tubes be placed anteriorly and posteriorly through separate, tunneled incisions, usually 28 Fr and 32 Fr. Pericostal sutures, usually four in number, of #2 polyglycolic acid are used. We have not found drilling of the lower rib to be of benefit. The muscle layers are closed with running 0 polyglycolic acid, the subcutaneous fascia similarly with 2-0 polyglycolic acid, and the skin at

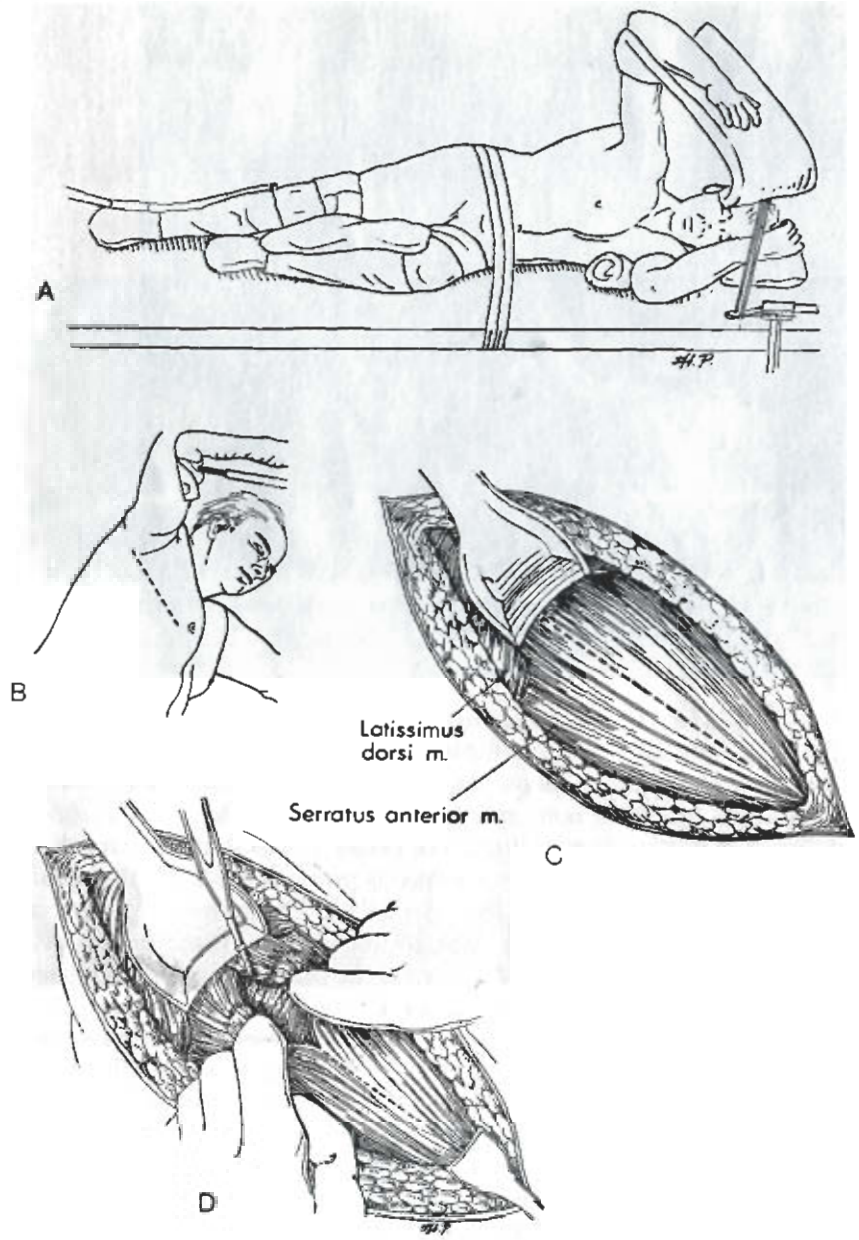

Figure 2. Axillary thoracotomy. *A*, The arm is abducted 90 degrees. *B*, The incision is made directly over the interspace selected for entry into the chest. *C*, The latissimus dorsi muscle is retracted posteriorly, and the serratus anterior muscle is split in the direction of the fibers. *D*, The posterior split of the serratus is stopped before encountering its long thoracic nerve.

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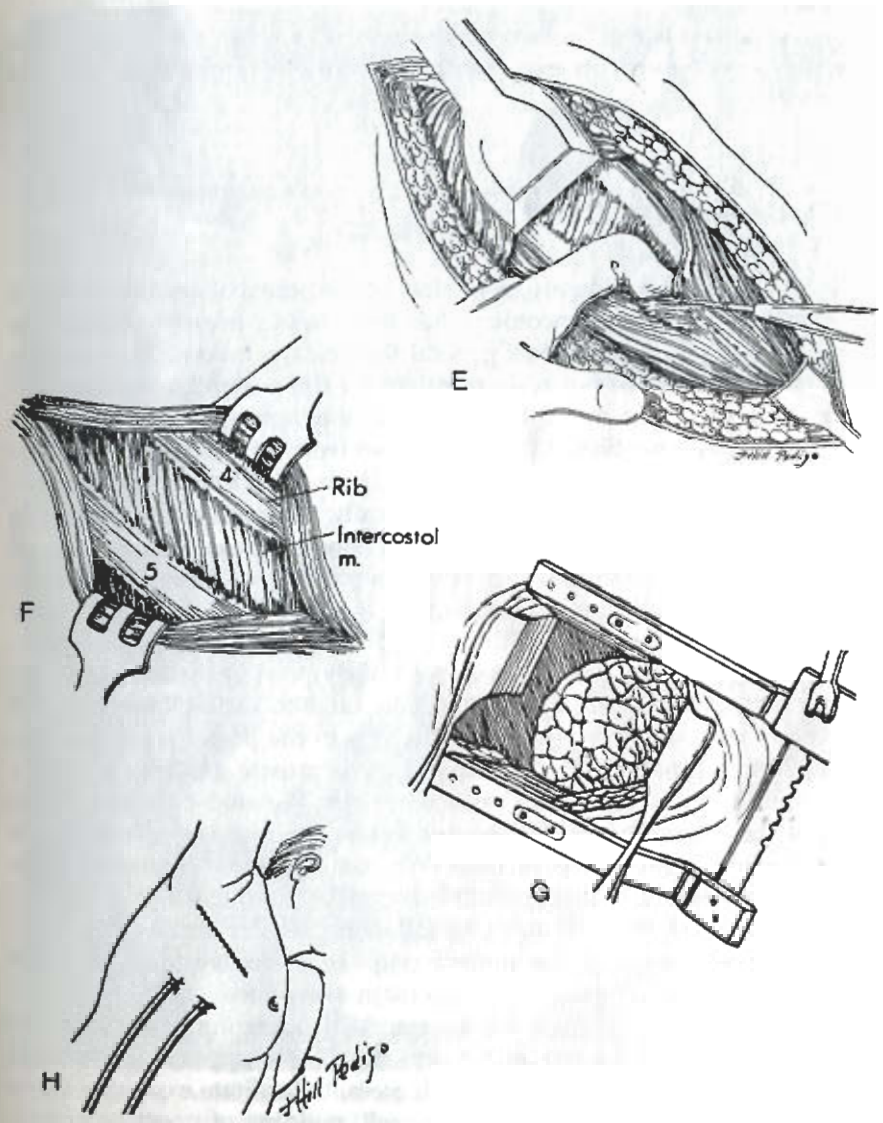

Figure 2 *(Continued)*. *E*, The electrosurgical unit aids in the split. *F*, The intercostal muscles are divided over a longer plane than the skin incision. *G*, Two retractors are helpful. *H*, Skin closure and chest tube size are at the discretion of the surgeon (*From* Fry WA: Thoracic incisions. *In* Shields TW (ed): General Thoracic Surgery. Philadelphia, PA, Williams & Wilkins, 1994, pp 385–386; with permission.)

the preference of the surgeon, usually with a running 2-0 nylon. If there is no air leak whatsoever at the time of closure, we occasionally use a single chest tube.

The posterolateral thoracotomy provides a large operative field, and we should not forget its exposure benefits in our efforts to be modern surgeons.

LATERAL THORACOTOMY

The lateral thoracotomy, sometimes called the axillary thoracotomy or a muscle-sparing thoracotomy, has become our favored incision for entry into the thorax for most general thoracic operations. The opening and closing times are much shorter than for the posterolateral thoracotomy, and there are multiple reports documenting less postoperative pain.[2, 7, 10, 13] As mentioned previously, we tend to eschew this incision for repeat thoracotomy, when we anticipate significant pleural adhesions, and when we anticipate a technically complicated operation. In recent years, there have been many variations on the details of a lateral muscle-sparing thoracotomy.[2, 3, 4] Our preference has been to make an incision over the desired interspace—the fourth for upper lobectomy and pneumonectomy, the fifth for middle and lower lobectomy—to retract the latissimus dorsi muscle posteriorly, to split the serratus anterior muscle in the direction of its fibers, and to incise the intercostal muscles from the anterior curve in the ribs to the posterior appearance of the longitudinal fibers of the sacrospinalis muscle group (Fig. 2). We have found it unnecessary to raise skin flaps. We stop posterior extension of the separation of the serratus anterior before we encounter the long thoracic nerve to the serratus. We continue to be impressed with the limited amount of postoperative discomfort, and the lack of impairment of arm and shoulder mobility following axillary thoracotomy.

The positioning of the patient (Fig. 3) is similar to that of the posterolateral thoracotomy with two main exceptions: (1) The patient's back should be at the edge of the standard operating room table, to facilitate positioning of the upper arm, and (2) the upper arm is placed on an arm sling and abducted at 90 degrees, to facilitate exposure. Once again, attention is paid to the axillary roll, padding of pressure points, and establishment of mechanical means of prophylaxis against deep vein thrombosis when risk factors for same are present.

Ginsberg, Hayward, and Bellamy[2, 3, 7] have described using a vertical incision for the lateral, muscle-sparing thoracotomy, but we have not found that to be necessary, though the incision we make over the desired interspace often tends to be more vertical than horizontal. Mackinlay[9]

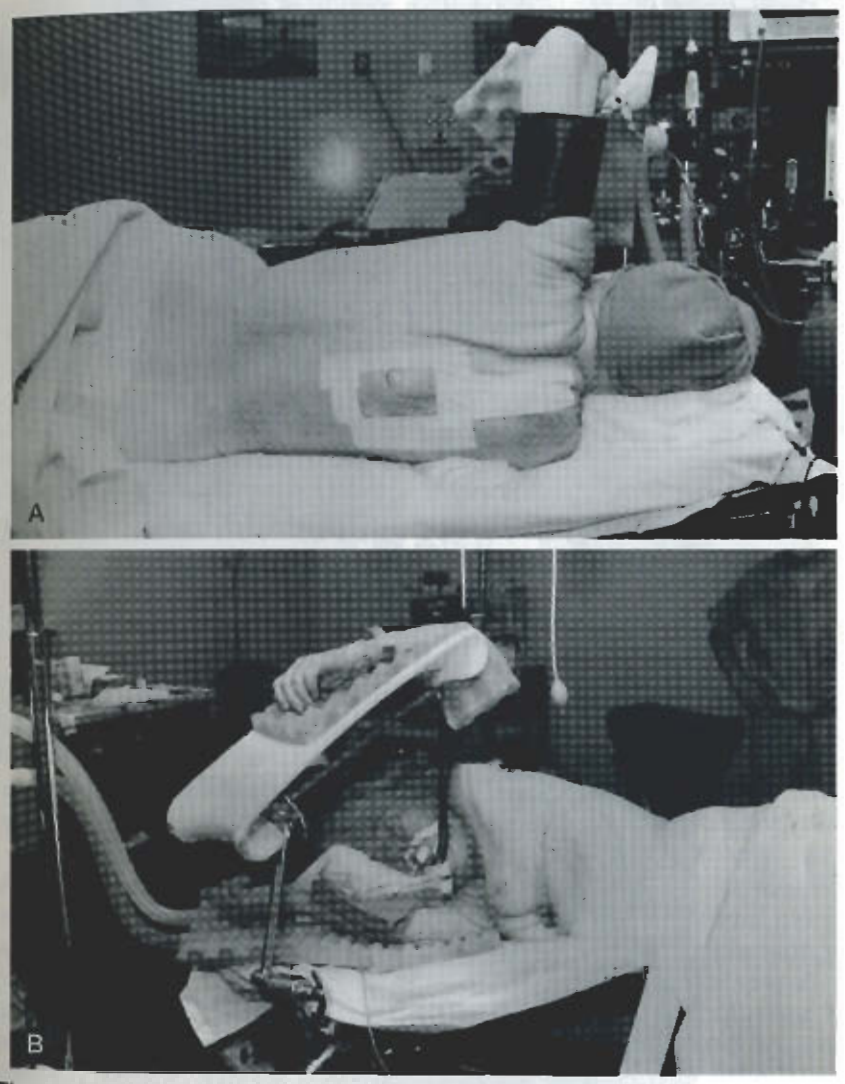

Figure 3. Axillary thoracotomy. *A*, It is advantageous to have the patient's back at the edge of the table. Note the axillary roll and the epidural catheter. *B*, A double lumen tube greatly facilitates exposure. Foam padding is placed under both of the elbows. The arm holder we prefer is called a Krause arm support (Amsco, Erie, PA). Special attention must be paid to padding of the elbow on the arm support.

has suggested that deliberate section of the first branch of the long thoracic nerve to the serratus anterior muscle to facilitate exposure produces no significant postoperative motion impairment, but we have not found such deliberate section necessary. Certainly, the raising of skin flaps has not been necessary at all in our experience with this incision.

Chest tube placement and closure of the musculofascial planes are similar to that of the posterolateral thoracotomy with #2 polyglycolic acid for the pericostal sutures, usually three in number; running 0 polyglycolic acid to the serratus fascia, and 2-0 or 3-0 polyglycolic acid to the subcutaneous fascia. Our preference for the skin closure is an intracuticular "pull out" suture of #1 nylon or prolene.

There are many variations of these muscle-sparing incisions. Hayward[7] describes anterior mobilization of the attachments of the serratus anterior muscle to avoid the need to split the muscle. Holmes' group[3] describes anterior retraction of the serratus anterior from an approach in the auscultatory triangle. Certainly, major credit should go to the surgeons from France who have consistently popularized this incision, which was also described by Schulze from South Africa.[10, 11]

Accessory (Utility) Incisions

The advent of video-assisted thoracic surgery (VATS) has led to further modification of surgical approaches to the thorax. After initial attempts to perform VATS procedures entirely through thoracoscopy ports, we have relied more recently on an anterolateral accessory or utility incision to gain entrance to the pleural space (Fig. 4). It is usually made over the fourth or fifth interspace and is 4 to 5 cm in length. Entrance to the pleural space is made by gentle blunt dissection. A double lumen tube is in place, and the "up lung" is occluded by the anesthesiologist. Once the pleural space is entered, the surgeon palpates by finger inferiorily and posteriorly, and a small incision is made over the seventh or eighth interspace to allow passage of a size 10 port for a standard thoracoscopy camera. Often simple thoracoscopic procedures can be performed with these incisions alone. It is often necessary, however, to make a second utility incision of 3 to 4 cm in length posterior, usually in the sixth interspace between the spine and the medical border of the scapula, to facilitate passage of stapling devices, forceps, and other surgical devices. These small utility incisions are made with a scalpel, and the deeper entry into the chest is made usually bluntly with Mayo scissors. In recent years, we have found ourselves using fewer trocar type ports in doing our VATS procedures.

Closure of a utility incision does not require pericostal suture.

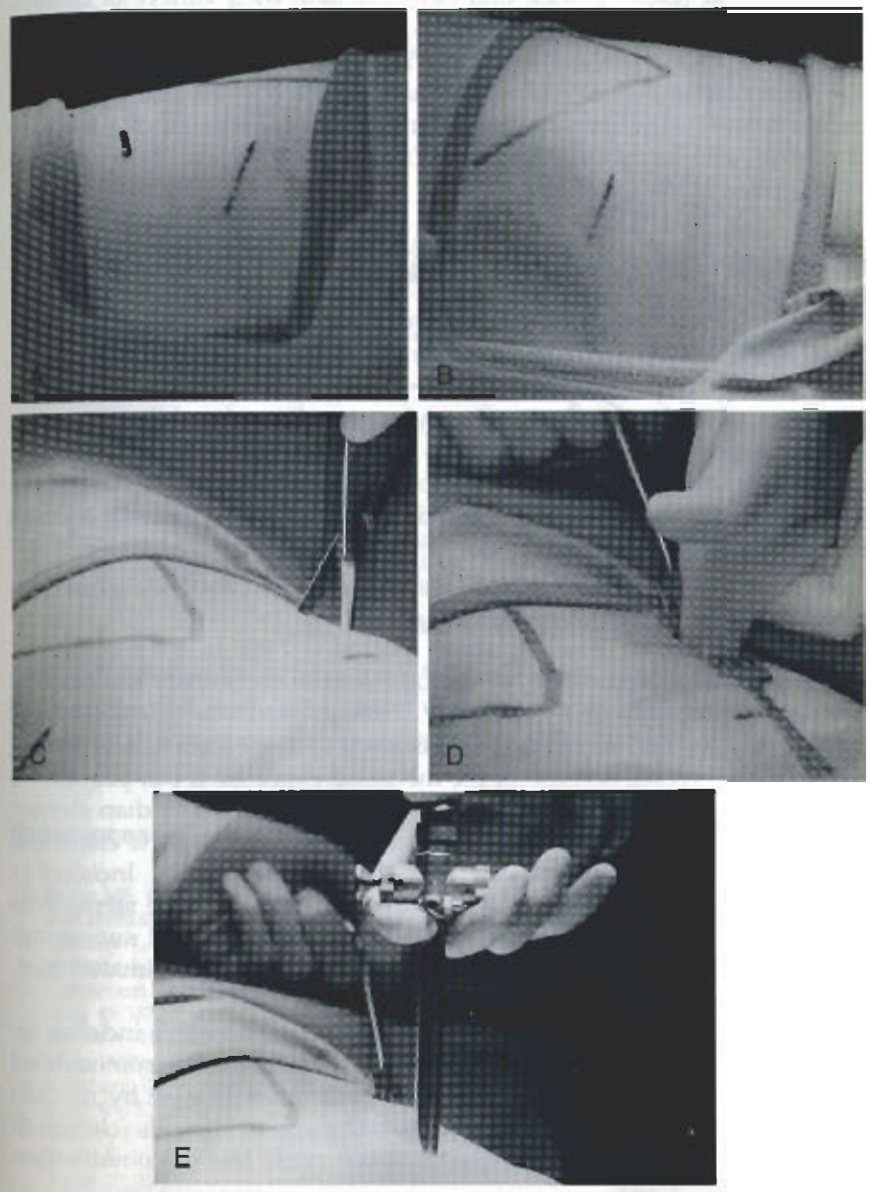

Figure 4. Accessory (utility) incisions. *A*, Anterior view. Anterolateral incision marked over the fifth interspace. Line for port placement marked at the eighth interspace. *B*, Posterior view. Proposed site of secondary utility incision between medial border of scapula and spine. *C*, Anterior entry through accessory incision can be made bluntly with a Mayo scissors. *D*, Exploring for adhesions via the accessory incision. *E*, Placing the camera port.

Generally, we place a few interrupted polyglycolic acid sutures in the muscular and fascial planes, and close the skin by a variety of means. At the time of closure of VATS utility incisions, local infiltration with a long acting local anesthetic agent such as 0.5% bupivacaine with adrenalin is recommended. We have also had favorable experience placing a paravertebral, extrapleural catheter for continuous infusion of a mixture of narcotic and local anesthetic agent (such as fentanyl and bupivacaine) as described by Grant.[6]

MEDIAN STERNOTOMY

The median sternotomy is the "work horse" of the cardiac surgeon. It certainly has its place in general thoracic surgical procedures, although its popularity for operations beyond the mediastinum seems to have waned in recent years.[4] It is still very appropriate when bilateral intrathoracic exposure is required, such as when simultaneous bilateral resection of pulmonary metastases is performed, when surgical treatment for bilateral spontaneous pneumothorax is considered, and for lung volume reduction procedures.

COSTOTRANSVERSE STERNOTOMY

The clamshell, crossbow, or costotransverse sternotomy has been in the armamentarium of the thoracic surgeon since the early days of cardiac surgery, and recently, it has received increased attention by lung transplant surgeons, because of the increased exposure it can provide to both pleural spaces when compared to that provided by median sternotomy (Fig. 5).[12] Baines[1] has reported a recent series using the clamshell incision for bilateral pulmonary and mediastinal tumors. Incision is made bilaterally over the fourth or fifth interspace, and the sternum is divided with a saw. Closure is accomplished by pericostal suture but accompanied by several Kirschner wires into the reapproximated sternum to prevent override and shift of the sternal ends.

Adequate exposure can be obtained by this clamshell incision by having the patient's arms positioned at the sides. It is not recommended for bilateral operations that can be accomplished with ease by median sternotomy because of the extra time to make and to close the clamshell incision. Furthermore, this incision does not cause less discomfort than a median sternotomy.

CONCLUSION

There are many ways to gain access to the chest. In recent years, there has been a rediscovery of the clamshell incision, an evolving concept of the utility incision for VATS, and a continued emphasis on the importance and usefulness of the muscle-sparing axillary thoracotomy, which continues to be our most frequently used incision.

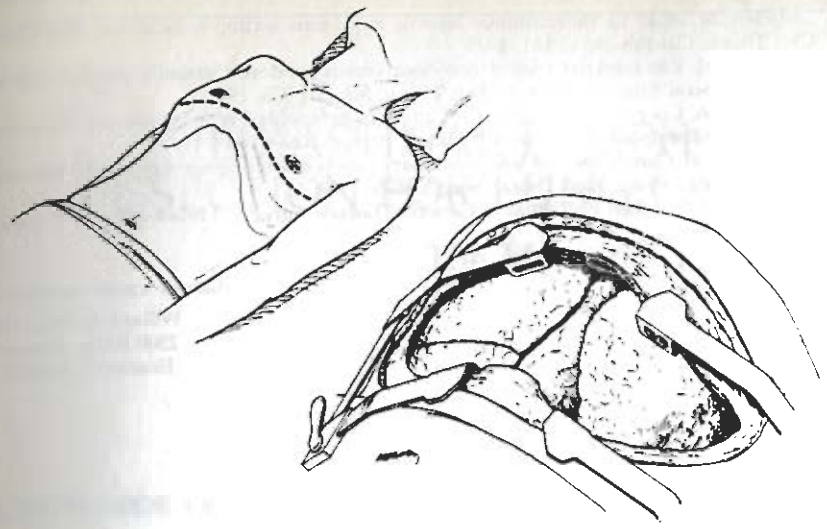

Figure 5. Clamshell incision is preferred for bipulmonary lung transplantation. Patterson and colleagues emphasize that adequate exposure can be obtained with the patient's arms at the side. (*From* Paterson GA, Cooper JD: Lung Transplantation. *In* Shields TW (ed): General Thoracic Surgery. Philadelphia, Williams & Wilkins, 1994, p 1075; with permission.)

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MEDIASTINAL LYMPH NODE DISSECTION FOR LUNG CANCER

The Memorial Experience

Nael Martini, MD

LYMPH NODE EVALUATION

Regional node dissection is an accepted part of the surgical treatment of many solid tumors. It was applied first to breast cancer in 1894 by Halsted[13] in conjunction with radical mastectomy. It was extended later to other malignancies that included head and neck cancers, gastrointestinal neoplasms and melanomas. We, at Memorial Hospital, first used regional lymph node dissection in the management of resectable lung cancers in 1949 and observed that some patients experienced long-term survival when the positive regional lymph nodes also were removed.[4] Our technique of en bloc dissection was described initially by Cahan[3, 4]; however, a problem at the time was the lack of a lymph node staging system that provided a distinction between hilar and mediastinal nodes and identification of specific nodal stations in the mediastinum.

Mediastinoscopy was popularized subsequently and access to the paratracheal and other subcarinal lymph nodes was perfected.[8, 10, 25–28] Most surgeons, however, performed mediastinoscopy as a diagnostic procedure, limiting their mediastinal exploration to the paratracheal region with biopsy specimens of only one or two nodes that were used to simply document the presence of N2 nodal metastasis.

In 1966, Cliffton,[5] at our institution, devised a lung cancer staging system and a lymph node nomenclature that we used for a brief period

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