

Pneumomediastinography: Techniques for Studying Intrathoracic Lymphadenitis

B.K. Sharov

Introduction

Accumulated experience from 500 pneumomediastinographies performed by various means is the background for the choice of approach we believe best suited to the pathology and site of each lesion. Gas was introduced by transsternal, paraxiphoid, and less frequently retromanubrial approach. Presacral and subcotal-subdiaphragmatic approaches were used for indirect gas introduction

Direct Methods

The best visualization was achieved with a minimum volume of gas introduced into the mediastinum. This is possible when gas accumulates under the lower pole of the pathologic process. In some cases it is necessary to introduce large volumes of gas to reveal the site of the lesion. Sufficiently distinct mediastinal organ visualization is achieved when comparatively small gas volumes (400 to 600 ml) are introduced by means of direct pneumomediastinographic methods. However, in such cases, inserting the needle may give rise to complications.

The puncture of a large vessel, vein, aorta, or injury to the pleura accompanied by the development of pneumothorax is possible with the retromanubrial approach (6). There may be injury to the common carotid artery, the jugular vein, and the esophagus (4, 8) with transtracheal (6) and paratracheal (13) needle insertion. Almost 25% of the patients examined by the retroxiphoid approach suggested by *Baccaglioni* has gas in the pericardial cavity (2, 10).

A sufficiently distinct visualization of the posterior mediastinum is obtained by means of the paravertebral method (11). However, injuries to the aorta, the large veins, and the

pleura are often observed in these cases (*V.P. Demidov et al.*, 4, 8). The danger of injury to large vessels and the esophagus also exists with the transbronchial approach (9). Such complications are mentioned by *Pegrim, Riha* and *Simecek* (12), who used this method. Pneumothorax occurs quite frequently when gas is introduced intercostally and retrosternally (14). In addition to being complex, the above-mentioned direct methods may often cause complications.

In transsternal pneumomediastinography, we have no record of similar complications. On the contrary, the advantages have been defined clearly. It is apparently reliable for revealing all mediastinal lymph nodes, the aim of the investigation, for example, in the case of lung cancer. It is, however, dependent on the introduced volume of gas. The more gas, the more precisely peripheral lymphatic nodules are visualized, especially those of the tracheobronchial and paratracheal groups. In these cases, however, painful sensations are observed, and the general condition of the patient often worsens. Since the sternal puncture is carried out with a special needle having a wide lumen, it is possible to withdraw a certain volume of gas through the same needle, after having completed the roentgenologic examination, thereby relieving the patient (Fig. 1).

Up to 1000 ml gas may be introduced through the manubrium. The site of the puncture may be chosen at any point of the manubrium or the body of the sternum, depending on the position of the lower edge of the tumor or the anterior mediastinal cyst.

The problem is quite different if the tumor or the cyst is localized in the anterior mediastinum and adheres closely to the sternum. Here there is danger of injury from the needle

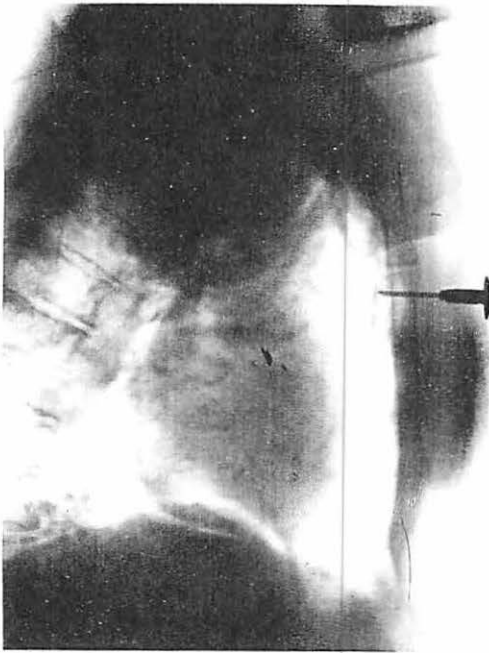


Fig. 1 Pneumomediastinography by transsternal approach. Needle has passed through the sternum and is in the mediastinum.

as it is guided through the sternum or close to it. In such cases we have used the paraxiphoid approach: The needle is guided into the angle on the right formed by the xiphoid and the body of the sternum. It was necessary to pass through a layer of soft tissue in order to penetrate into the mediastinum. We managed to orient the position of the needle by giving continuous Novocaine injections. As soon as we felt free passage of the solution, we stopped insertion of the needle and introduced the necessary volume of gas.

Indirect Methods

Any of the direct methods of pneumomediastinography may prove dangerous if a pathologic condition occupies the entire anterior mediastinum. In such cases it is advisable to apply the indirect approach. There are several modifications of the two main methods of indirect pneumomediastinography, i.e., the introduction of gas into the presacral (7, 16) or paravesical subcutaneous tissue.

Since it is impossible to regulate the gas volume penetrating the mediastinum, satisfactory visualization of the mediastinal organs is not always achieved and the rectum or the urinary bladder may be damaged. A matter of greater importance is the fact that the gas does not penetrate into the mediastinum immediately. Films are therefore, taken for several hours—and sometimes even the day after the insufflation. Among the indirect methods, the epidural and peridural approaches suggested by *Ciarla* (5) are well known and have been widely used by *Sansone* (16).

We have applied indirect presacral pneumomediastinography. We soon abandoned this method when the disadvantages were discovered. We consider the basic problem with this method to be the fact that a reliable visualization of the mediastinum is not assured. In trying to produce a pneumomediastinum, identical volumes of gas were introduced retroperitoneally in the majority of patients. In some cases unsatisfactory visualization of the mediastinal organs was noted since an insignificant volume of gas had penetrated. In others, almost the entire gas volume passed into the mediastinum and spread further over the neck and face. This is the reason why we now use the subcostal-subdiaphragmatic method which we developed. The advantage of applying such a method for mediastinal visualization is that the gas spreads freely in the subcutaneous tissue surrounding the peritoneum. This is due to the fact that the gas penetrates into the mediastinum from the presacral or prevesical subcutaneous tissues. If the gas enters the preperitoneal space, it must then also enter the mediastinum. The preperitoneal subcutaneous tissue lies just behind the anterior abdominal wall muscles, and the latter are attached to the costal arch, interweaving it with tendon fibers. If then the needle is guided strictly under the costal arch, it will be in the peritoneal subcutaneous tissue (Fig. 2).

The indirect technique of subcostal-subdiaphragmatic pneumomediastinography is quite simple. Local anesthesia of soft tissue at any point on the left or right hypochondrium is given with Novocaine solution. The same needle is then guided under the costal arch

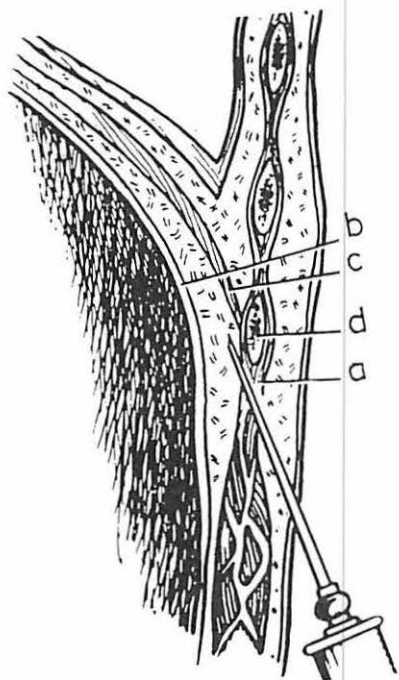


Fig. 2 Subcostal-subdiaphragmatic method of pneumomediastinography. Frontal section at the level of midclavicular line a) anterior abdominal wall muscles, b) peritoneum, c) diaphragm, d) costal arch.

along the posterior surface for 1 to 1.5 cm. It is necessary to keep the needle point behind the costal arch. Sometimes one manages to feel the posterior surface of the chest wall with the needle. This may be an orientation point for the correct position of the needle. First about 40 ml of 0.25% Novocaine solution is introduced additionally; the necessary gas volume is then injected. Compared with other indirect pneumomediastinographic methods, it is necessary with such an approach to introduce the minimum gas volume, i.e., the same volume used in direct pneumomediastinography. This is one of the advantages of the method. Another advantage is that complications rarely arise. None of the patients examined by such an approach have developed complications. Three times gas penetrated mainly into the retroperitoneal cavity enveloping the kidneys and the suprarenal bodies, thereby making them clearly visible, little gas was found in the mediastinum. Two to four

hours later, the visibility of the mediastinum did not improve. Such a phenomenon cannot be explained exactly; we suppose that it was associated with fibrosis or a defect in the subdiaphragmatic subcutaneous tissue development. Sometimes, even though the gas penetrated freely into the mediastinum, it poorly outlined the pathologic process. This was observed in cases of lymphogranulomatosis or malignant thymomas. The gas concentrated in those portions of the mediastinum which were tumor free and spread over the neck. Such a finding should not be regarded as one of the problems with the method; it is a diagnostic sign which shows the malignancy and the growth of the tumor through the mediastinal pleura.

Pneumomediastinography in Lung Cancer

In the case of mediastinal lymph nodes, the application of pneumomediastinography is most rational when searching for regional metastasis in patients with lung cancer. It is known that enlarged lymph nodes in the hilus of the lung and the paratracheal regions can be distinguished by ordinary roentgenologic examination. The advantage of pneumomediastinography, however, is that bronchopulmonary lymph nodes concealed behind the atelectatic shadow are revealed, some of the tracheobroncheal lymph nodes become visible, and their relation to the mediastinal organs is visualized.

The lymph nodes of the paratracheal regions can be revealed tomographically only when they are greatly enlarged. They are localized in front of or behind the superior vena cava; on the left, they are hidden behind the aorta and the left carotid artery and are revealed only when they have become outlined at the border of the mediastinal shadow. Normally, the ribbon-shaped shadow of varying widths is of the superior vena cava visible paratracheally on the right. Its medial contour merges with the trachea, but its external contour has even and clearly defined borders. This shadow disguises the small lymph nodes. In such cases the introduction of gas into the mediastinum may possibly create conditions for detecting the right paratracheal lymph nodes since the



Fig. 3 Patient P's pneumomediastinogram. Right upper lobe cancer. Single lymphatic nodule in the right paratracheal region. Pneumonectomy.

mediastinal pleura as well as the superior vena cava are replaced externally, thus revealing the paratracheal zone for examination.

Cancer of the right upper lobe bronchus with atelectasis makes the examination of the right paratracheal region even more complicated. The collapsed lobe is pressed on the trachea and gives an intensive shadow tomographically along the whole tracheal wall. Sometimes the tumor localized in the medial portions of the lobe closely adheres to the trachea. In the latter case, the operability will depend not only on the presence of metastases in the paratracheal lymph nodes but also on whether or not the tumor has grown through the tracheal wall. Pneumomediastinography easily eliminates these doubts since the collapsed lobe is driven back externally by the gas. As a result, the enlarged lymph nodes in the paratracheal regions become visible (Fig. 3).

Enlarged regional bronchopulmonary nodes are well revealed on pneumomediastinograms. This, however, is not a sign of inoperability; these nodes are removed together with the lung. The problem is different if the lymph nodes of the tracheobronchial or paratracheal groups prove to be enlarged. Even in such cases, evaluation must be made on an individual basis.

It has been estimated that not every enlarged lymph node in a lung cancer patient is involved with metastases. Lung cancer often develops on the background of chronic inflammatory involvement and is frequently accompanied by inflammation of the atelectatic lobe. It is quite natural, therefore, that such patients may have enlarged lymph nodes in the mediastinum. For this reason, the discovery of small single lymph nodes in one group is not a contraindication for surgery.

The signs of true inoperability revealed by pneumomediastinography are the growth of the tumor through the lung or metastases in the mediastinal organs and multiple metastases in the paratracheal and tracheobronchial lymph node (Fig. 4). If the tumor involves the mediastinal organs, the gas does not pass between the tumor and the mediastinum.

Depending on the localization of the cancer, a variable roentgenologic picture is observed pneumomediastinographically. It is closely associated with the shape of the regional lymph node metastases. In many patients with cancer of the main intermediary bronchus, the tumor localized close to the mediastinum spreads to the mediastinal pleura and organs rather quickly. For this reason cancer of the large bronchus is inoperable; the inoperability, however, must be determined. The direct sign of a mediastinal lesion is also demonstrated when less gas accumulates in the mediastinum on the impaired than on the uninvolved side.

Patients with cancer of the main or intermediary bronchus often reveal bilateral paratracheal lymph node metastases. This demonstrates that the cancer is far advanced and confirms the well-known correlation between the stage of the disease and the spread of the lesions over the bronchial tree.

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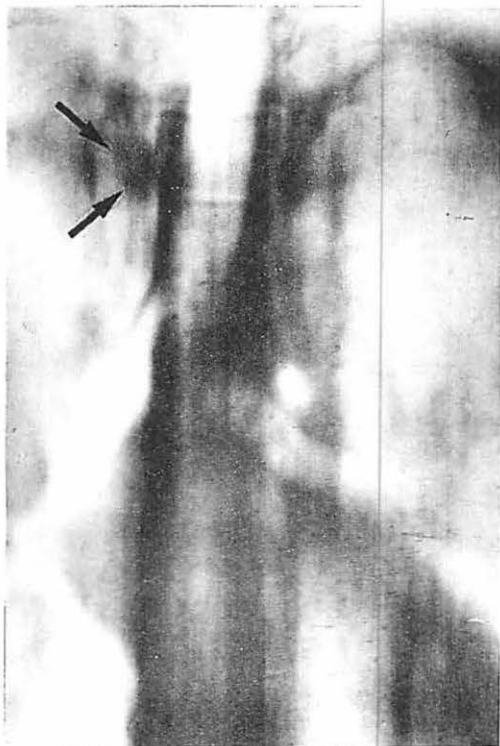


Fig. 4 Patient E's pneumomediastinogram. Multiple, enlarged lymphatic nodules in the right paratracheal zone. Thoracotomy.

The growth of the tumor through the mediastinal organs to lobe segments or peripheral parts of the lung, a sign of inoperability in patients with lesions in the bronchi, is countered less frequently. The inoperability of these patients is more often associated with the presence of unremovable metastases in lymph nodes of the tracheobronchial group and the lower portion of the posterior mediastinum.

With cancer of the upper lobe of the right lung, the nearest regional node is the superior vena cava lymph node. Later, nodes in the parasternal region and around the bifurcation become involved. In some patients the enlarged paratracheal lymph nodes were surrounded by a thin layer of gas. This sign indicates that lymph nodes do not grow through the adjoining tissues and can apparently be removed together with the mediastinal subcutaneous

tissue during the operation. This has been repeatedly confirmed by our observations. The possibility of radical surgical removal is more often questioned, and as a rule, patients prove to be inoperable if such nodes are large and connected to the mediastinal tissue.

The pathways of lymphatic metastatic spread from the lower lobe are also via the lymph node of the superior vena cava. At a certain stage of the cancer, this may be the only node involved and may, therefore, be removed surgically. Even in such cases, it is therefore, necessary to perform pneumomediastinography. In addition to the superior vena cava node metastases, enlarged lymph nodes in other parts of the region can also be determined in advanced cases. The paratracheal nodes on the side of the lesion may be involved or even the nodes on the opposite side.

In cases of cancer of the upper lobe of the left lung, crossed metastases frequently occur in the right paratracheal lymph node group since they are directly connected with those on the left. Left upper lobe cancer metastases are seldom single; their presence in the regional group, therefore, is a sign of inoperability in the majority of cases.

In patients with left lower lobe cancer, bronchopulmonary lymph nodes are involved first. Naturally, this in no way prohibits surgery. The cancer is usually considered to be inoperable if metastases develop in the lower part of the posterior mediastinum. The lower lobe is connected with this group of lymph nodes by means of direct lymphatic pathways. In advanced stages, enlarged lymph nodes develop in the paratracheal group as well (Fig. 5).

Pneumomediastinographic data indicate that this method, while important for revealing mediastinal enlarged lymph nodes and determining the spread of a tumor on the mediastinal pleura, ranks high in the roentgenologic examination of a lung cancer patient. It would however, be false to assert that all regional lymph nodes may only be revealed via pneumomediastinography. Often mediastinal vein visualization, radioisotope lymphography, and other methods are employed for



Fig. 5 Patient Ch's pneumomediastinogram. Left upper lobe bronchial cancer. Multiple, enlarged bronchopulmonary and paratracheal lymphatic nodules on the left. Thoracotomy.

this purpose. In a lung cancer patient, the evaluation of his operability by means of transsternal pneumomediastinography is often more reliable and less painful for him. In all other cases, the subcostal-subdiaphragmatic approach by indirect pneumomediastinography may be applied even though it is not as reliable as the direct methods of artificial mediastinal emphysema. It is, however, simple and complications do not develop.

Prof. B.K. Sharov, MD, Director of the Chelyabinsk Roentgenology and Radiology Medical Institute, Chelyabinsk, USSR

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