A New Method for
Anatomo-Radiologic Study of the Lung
After Resection*

MAURICE A. PETIT, M.D.  JANOS KURUCZ, M.D.  WALTER FLORANGE, M.D.
Colmar, France  Budapest, Hungary  Strasbourg, France
with the technical assistance of SUZANNE DOERR, Colmar, France

The chief interest offered by macroscopic anatomo-pathologic study of the surgical specimens obtained by resection of the lung consists, above all, of allowing a precise comparative study of the roentgenogram and its anatomic counterpart. For several years, we have endeavored to attain a more accurate correlation between the black and white x-ray films of patients, and the actual anatomic substrate of which the films are but a crude and indirect reflection.

Such a comparative survey can be made by directly dissecting the fresh surgical specimen, a method which allows only a crude correlation with an x-ray film.

The same survey can also be made after filling the surgical specimen with a fixative fluid and dissecting it into thin slices. It is the method followed by Gough and Wentworth1 or that of Christeller2 which does not clearly reveal three-dimensional changes. The bronchial tree, in particular, makes it difficult to follow the development of pathologic alterations on a section only a few tenths of a millimeter thick.

In the present work, we propose methods for such comparative study of the surgical specimen and the roentgenogram of the lung taken before operation, through a special procedure permitting radiography of the specimen placed in the proper position and roughly restored to its original shape.

Principles of the Method
Routine radiography of any surgical specimen of lung without preparation is not conclusive; it is the result of contrasts due to different penetration of x-rays according to density of tissue. When the pulmonary parenchyma is collapsed, which is the case after removal of the surgical specimen, the obstacle it offers to x-rays is nearly the same as that offered by the denser pathologic lesions it includes, and nothing valuable for diagnosis can be seen.

Radiography of the same specimen after simply inflating the bronchi is also adequate, for the concomitant dehydration of the lesions renders them not less opaque to x-rays than the adjacent parenchyma, and thus the image of lesions does not contrast strongly enough with the surrounding normal lung parenchyma.

It will then be found expedient to intensify contrast by impregnating the tissues with a salt of some heavy metal, lead nitrate for instance, which is the least expensive.4 As these salts impregnate normal tissues as well as the lesions, examination of all impregnated parts becomes possible. On x-raying the specimen, clear-cut pictures may be observed, because there will be a sharp contrast between the impregnated regions and the inflated areas of the lung. The normal parenchyma will be seen as a delicate honeycomb, whereas the bronchial walls which are of a denser texture, as well as the pathologic changes, will be clearly set off by contrast.

Technique of the Procedure
(1) Fixation of the surgical specimen
The surgical specimen should be inflated,
avoiding too much pressure, by injecting the bronchial system with a solution of 40 per cent lead nitrate in distilled water. One should see to it that the fluid reaches all the pulmonary regions, so that no segmental or subsegmental bronchus is missed. The surgical specimen thus prepared should be kept for 48 hours in a flat bottomed container filled with the same contrast fluid.

Subsequently, the specimen is removed and the bronchi are catheterized by means of catheters, the sizes of which perfectly fit the segmental, subsegmental or lobar orifices. It is imperative to reach every pulmonary region. The catheters may be fastened either by means of thread tied around the bronchus, or by suturing if the bronchial stump is found to be too short.

Finally, the catheters are connected by means of Y tubes to an air-pump (Fig. 1), which, equipped with a very accurate flowmeter, inflates the surgical specimen under even, adjustable pressure, the flow being easy to check. If necessary, screw-clips can be placed on some of the catheters, to control the air flow. Of course, the delivery of the pump should be adjusted to possible leaks in the parenchyma; yet in case of a perfectly air-tight specimen, a very small flow, about one liter per minute, is quite enough. A very sensitive flowmeter is therefore essential. One must be able to control the pressure of air very closely in order to avoid accidental rents and artifacts due to too much pressure. One must endeavor to restore the surgical specimen to the volume it occupied normally on deep inspiration.

The surgical specimen is kept continuously inflated, and is hung up by its hilum to avoid distortion, until the fixation process is finished. To avoid distortion, a few authors have recommended inflating the specimen under partial vacuum. The surgical specimen is hung in a partial vacuum, its bronchial system communicating with the atmosphere outside. We are convinced that either method allows only an approximate restoration of the parenchyma to its original shape. Manipulations during operation are a cause of distortion; on the other hand, once it is removed from the thoracic cage and the neighboring parenchyma, the lobe or the segment can at best, be brought back to something resembling its normal status.

**Figure 1:** Fixation of the surgical specimen. Left lower lobe (L) and a dorsal segment of the right upper lobe (D) hung up by their hilum while the catheters in the bronchi connected by Y tubes to the flowmeter (F) of the pump (C).
The time of inflation varies according to the importance of the surgical specimen and the amount of air that is needed. It may take from two to five days, after which the fixation process is finished, and the specimen is ready for radiography.

(2) Radiography of the surgical specimen

For taking such roentgenograms, we have used Kodak “Definix” film. Later, experience revealed good results with Kodak “Regulix” standard films (without screen).

First, two exposures of the whole specimen are made, one in front-view (Fig. 2), the other in profile. To do so, we use 100 KV 40 M.A.S. 300 milliamperes, at 100 cm. distance. Of course, these indications depend on the size of the surgical specimen and, above all, the thickness of the visceral pleura.

When this has been done, the specimen is cut into parallel slices, 15 to 20 mm. thick, so that their plane corresponds to the tomographic sections of the patient's pre-operative x-ray films.

The thickness of each section should be measured carefully, starting, as in the case of the corresponding tomographs, with the most distant plane. This will make the various comparisons much easier, when it comes to the anatomo-radiologic collation. A roentgenogram of these sections requires on the average 80 KV 40 M.A.S., and 500 milliamperes, at a distance of 100 cm. It is obvious that these figures are given only for guidance and are subject to variation according to the nature of the anatomic specimen. As a rule, it will be found preferable to over-expose a little, which allows correction, if necessary, by cutting the time of development.

Results

The x-ray films of the whole surgical specimen (Figs. 3 and 4) are useful for finding the more important reference marks, thus facilitating the interpretation
of results and especially the general orientation of the pictures in space. On the other hand, they will give a good basis when collating with the patient's standard roentgenograms.

Only radiography by serial sections allows a highly accurate analysis of pictures (Fig. 5). On the other hand, the whole series permits a faithful reconstitution in space.

Lead nitrate covers the walls of all of the air passages with a delicate film and outlines them sharply. First, the bronchi proper, the lobar bronchi, then their segmental, and subsegmental divisions, then, the bronchioles which are easy to identify, for, according to Galy's definition, they divide rapidly at nearly every millimeter. We get a true bronchogram "en couche mince," and a very precise one at that.

Moreover, the lead nitrate, after its passage through the air passageways, permeates the web of the parenchyma which is seen as a delicate texture of tiny meshes.

If a lesion alters that network, the lead nitrate permeating it reveals it at once in a dense, sharp, precise, indelible image. Still more important, lead nitrate discloses the existence of lesions in the interior of a section, lesions that might otherwise be brought to light only by a series of thinner sections, which unfortunately would isolate them from their anatomic surroundings.

**Discussion of the Method**

This method, above all, allows the study of pulmonary anatomo-radiologic pathology in connection with the bronchial and bronchiolar systems. It permits precise macroscopic study, easily related to three dimensions, directly comparable with the patient's preoperative roentgenograms. The impregnation with a thin coat of lead nitrate ("en couche mince") achieves exceptionally sharp pictures. The method, moreover, permits the usual histo-bacteriologic survey by simply rehydrating for 24 hours under vacuum, in isotonic saline solution,

![Figure 3: Roentgenogram of the whole specimen, front view. The figure shows a right upper lobe. Resection for sclero-caseous pulmonary tuberculosis, with numerous bacilli.](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21390/ on 04/02/2017)
the fragments of parenchyma which are deemed of interest. One must, of course, keep in mind a few alterations due to previous desiccation.

In closing, we want to point out the disadvantages and limitations of our method. The permeation of tissues with lead nitrate and the consequent desiccation cause a certain friability of the parenchyma that must be taken into account when sectioning the surgical specimen in parallel sections. This permeation also imparts to hard tissues, especially to pachypleuritis, a degree of hardness that not only makes difficult their sectioning, but also their radiography as a whole. Finally, it causes a greyish appearance of the parenchyma, which may, at the beginning, confuse macroscopic interpretation.

Other inadequacies pertain to the method of fixation itself, through inflating the lung. This method preferably will not be applied to surgical specimens showing gross leaks that cannot be stopped.

Finally, the inflation of the bronchial system does not allow the previous injection of the vasculature with an opaque x-ray medium; the blood vessels collapse and the superimposition of bronchial and vascular pictures does not make things easier as far as radiography is concerned.

CONCLUSION

As a complement to the various methods already set forth for the study of resected lung specimens, the method we have devised completes the new idea of "the third dimension." We no longer examine surgical specimens in thin sections, the few tenths of a millimeter thickness of which is but a small snapshot of the structure of the bulk of the lung, but we propose a method allowing the examination of the spatial distribution of all pathologic alterations, parenchymal as well as bronchial, without losing sight of their mutual relationship. Furthermore, our method permits direct collation of the anatomo-radiologic findings in the surgical specimen with tomo-

Figure 4: Roentgenogram of the same specimen in profile. The main lesion in the apical segment is clearly seen, as well as the full extent of the bronchial tree. The specimen measures 170 mm. from front to back. It will be cut into seven slices parallel to front plane.
FIGURE 5: Roentgenogram of the slice of lung from 85 mm. to 105 mm. from posterior plane. It shows the anterior part of the apical segment and, a little below, the posterior part of the ventral segment. It contains many nodules. A few bronchial deformities are apparent. Note that the method permits very clear visualization of the bronchioles.

grams of the lung obtained as part of the clinical observation of the patient.

Our method of inflating the surgical specimen after lead impregnation permits study of the air passages down the final termination of the bronchioles which are not, by this method, isolated from the surrounding parenchymatous lesions.

Finally, our method does not rule out the possibility of customary histo-bacteriologic examinations, after proper rehydration.

SUMMARY

A new method is presented for fixation of the pulmonary parenchyma through inflation after lead impregnation, in order to make radiographic studies of surgical specimens more effective. This method allows comparison of films showing the specimen and sections of it with those taken prior to surgery. It also allows a particularly sharp view of any lesions inside the specimen, and of the whole bronchial system down to the most distal bronchioles. The same method, after rehydration of the specimen, permits the usual histologic and bacteriologic examinations.

RESUMEN

Se presenta un método nuevo para la fijación del parénquima pulmonar mediante la inflación después de la impregnación con plomo, a fin de hacer estudios radiográficos de los especímenes quirúrgicos con mayor eficacividad. Este método permite la comparación de las películas que muestran el espécimen y sus secciones de ella con las tomadas antes de la operación.

Permite, además una vista particularmente definida de las lesiones dentro del espécimen y del árbol bronquial completo hasta los bronquiolos más distantes. El mismo método después de rehidratación del espécimen permite los estudios histológicos habituales, así como los bacteriológicos.

RESUMÉ

Les auteurs proposent une nouvelle technique de fixation du parenchyme pulmonaire par insufflation après imprégnation des tissus par le nitrate de plomb afin de pouvoir radiographier utilement les pièces d'exérèse. Cette technique permet de comparer les clichés obtenus à partir de la pièce opératoire avec ceux obtenus sur le malade lui même avant l'intervention chirurgicale.

Elle permet aussi de rendre particulièrement visibles toutes les lésions contenues dans le pièce opératoire ainsi que tout le système bronchique jusqu'aux ultimes bronchioles. Cette technique permet enfin de procéder, ultérieurement, après réhydratation, aux examens histologiques et bacteriologiques habituels.

ZUSAMMENFASSUNG


REFERENCES

CARIDIOPATHY IN MUSCULAR DYSTROPHY

In a previous communication, certain electrocardiographic changes, described under "myopathic pattern" were reported by Drs. P. L. Wahl and S. S. Manchanda, Amritsar, India, on a series of patients suffering from various types of muscular dystrophy. The present report deals with approximately 130 cases of myopathy in whom detailed clinical, radiologic and electrocardiographic investigations were carried out to evaluate the incidence and nature of cardiac changes. In some cases, these were supported by serum enzyme, vectorcardiographic and cardiac catheterization studies. Interesting data of two cases with frank congestive heart failure along with necropsy findings in one were further discussed. The rarity of congestive heart failure in spite of the high incidence of incipient cardiac changes was emphasized.

Presented at the 7th International Congress on Diseases of the Chest, New Delhi, India, February 20-24, 1963.

SURGICAL ANATOMY OF CORONARY ARTERIES

A classification of coronary arteries was suggested by Dr. Angelo M. May, San Francisco, Calif, using the term atrioventricular vessels and intraventricular vessels which are more indicative of their localization and function. The location of the coronary orifices above the leaflets of the aortic valve was clarified and the location of the orifices in regard to the anterior posterior axis was found to be quite variable. Classification of intercoronary collaterals was suggested, namely, bypass collaterals, inter-

TUBERCULIN NEGATIVE TUBERCULOSIS

A negative tuberculin reaction, in titres up to and including 1 mg. OT as a rule implies that the patient has not been exposed to tuberculous infections. Dr. Erik Hedvall, Upsala, Sweden, stated that there are exceptions. For example, if BCG vaccination is given orally, the tuberculin reaction is usually negative afterwards. Negative reaction also occurs during the incubation period and sometimes during the post-primary period. Well known is the disappearance of positive reaction in tuberculous meningitis, miliary tuberculosis, tuberculosis in patients in a moribund or cachectic state, also in measles, whooping-cough, sarcoidosis. Sometimes the negative reaction is of a temporary nature. Less well known, however, is that the tuberculin reaction may be negative in cases with tuberculous changes in spite of the fact that the general condition of the patient is good and none of the diseases listed above is present or has recently been present. An account was given of 35 cases of the last-mentioned type.

Presented at the 7th International Congress on Diseases of the Chest, New Delhi, India, February 20-24, 1963.