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A THREE-STEP METHOD FOR THE DIAGNOSIS OF SOLITARY PULMONARY NODULES*

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ABOUT 25%[1] to 50%[3] of patients with primary bronchial cancer are estimated to be seen by the physician when the lesion is still manifest as a solitary pulmonary nodule. Prompt removal or eradication at this stage is advisable. But thoracotomy and biopsy of benign nodules carries a small mortality and a significant morbidity. It would therefore be desirable to utilize less hazardous methods of diagnosis. This paper is a report on what we believe to be such a method.

PATHOLOGY

The diseases and anomalies which result in the production of a solitary pulmonary nodule are legion. The differential roentgen diagnosis requires consideration of:

1. Inflammatory lesions (pneumonia, abscess, granuloma, etc.).
2. Benign pulmonary tumour and cyst (hamartoma, etc.).
3. Malignant pulmonary tumour (primary and metastatic).
4. Mediastinal tumour projecting into the lung field (neuroma, teratoma, etc.).
5. Pleural tumour (mesothelioma, fibroma).
6. Vascular lesion (arteriovenous fistula, infarct, aneurysm, sequestration, anomaly).
7. Miscellaneous lesion (pneumoconiotic nodule, localized fibrosis, etc.).

The inflammatory granulomas, benign tumours and miscellaneous vascular lesions may be grouped for purposes of the present discussion as "benign" nodules. The malignant neoplasms may be grouped as "malignant" nodules. In a review of some 2000 cases, both collected and personal, and mostly surgical in origin, we have found the following recorded pathological distribution: granuloma (including focal pneumonitis), 44%; benign lesion (tumour, cyst, etc.), 24%; malignant lesion, primary, 26%; malignant lesion, metastatic, 6%.

Holin and associates[2] found in a mass survey in Cleveland that about 3% of solitary pulmonary nodules proved to be malignant; Taylor *et al.*[4] in a

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TABLE I.—SOLITARY PULMONARY NODULES—PER CENT MALIGNANT

Author and date	*Number and source of cases*	*Per cent malignant*
Holin *et al.*, *Pub. Health Rep.*, 1956	666 (Cleveland survey)	3
Garland, *Chicago M. School Bull.*, 1958	1956 (personal and collected)	26 (range 16 - 37)
Taylor *et al.*, *Ann. Surg.*, 1958	236 (Fitz, A. H.)	9.7

large general hospital found that about 10% were malignant: in many surgical series about 25% were malignant. The proportion will therefore vary with the nature of the sample studied, and will of course increase with age.

DEFINITION

The solitary pulmonary nodule may be defined as one:

a. lying within the pulmonary parenchyma,
b. apparently solitary on conventional roentgenography.
c. circular or ovoid in shape, and
d. less than about 6 cm. in diameter.

METHOD

The method which we employ is termed a three-step method. It consists essentially in thorough *radiological* examination at the patient's first visit, brief *clinical* examination, and pertinent *laboratory* examination. Since most of these nodules are discovered as silent roentgen shadows, it is stressed that the first step is the attempted completion of definitive or thorough radiological examination; the next is evaluation of the anamnesis; and the last (and sometimes elective) step, clinical laboratory study.

I. *Radiological Procedure and Criteria*

Complete the roentgen examination by stereoscopic posteroanterior, or oblique, or lateral projections, depending on the location of the opacity. Use posterior lordotic views, heavy density views, tomograms or fluoroscopy as indicated. Fluoroscopy will permit rapid detection of variations in size of vascular nodules such as arteriovenous fistulas. Heavy density views and tomograms will aid in the detection of calcium (and its location as being central or peripheral) and of cavitation. Fluoroscopy has the advantage of requiring the radiologist to see the patient in person, permitting him to obtain a brief initial history including determination of such key points as symptoms, previous chest roentgenographic examinations, recent surgery, etc., and, most important, of reassuring those who become apprehensive by virtue of the unusually thorough examination.

The nodule is analysed particularly from the following points of view:

Is the opacity a true solitary nodule as defined?

Are its margins sharp, fuzzy or otherwise?

Is it adjoined by fine strands (linear opacities) or satellite nodules?

Is there calcium within it or at its margin? Is it cavitated?

Has it changed in size from previous chest films?

The majority of benign lesions as above defined have relatively sharp borders; the majority of primary malignant tumours have indefinite, irregular or fuzzy borders. However, it should be noted that a primary bronchial carcinoma *may* have a very sharp border, especially when smaller than 1 cm. in diameter, and that therefore this one feature alone is not decisive.

Small linear densities connecting the nodular opacity with the pleura or with the hilum are more common in inflammatory than neoplastic disease; satellite nodules may be present with both primary carcinomas or granulomas.

Centrally located calcium is almost pathognomonic of a solitary benign lesion (granuloma, hamartoma, etc.). However, marginally located calcium is not decisive. Primary carcinomas may arise behind a small calcific residue of former infection. These remarks pertain to calcium as seen in roentgenograms of living patients, not in excised surgical or postmortem specimens.

Cavitation, when associated with a thick or irregular wall, is suggestive of neoplasm. Change in size or shape of the nodule from that present in previous roentgenograms may occur with both benign and malignant nodules. Absence of change over a long period (say over two years) favours benignity. Increase in size over a short period (say three months), especially if the patient is more than 45 years of age, favours malignancy. While many bronchial cancers may have a long pre-invasive or localized microscopic phase, most (about 80% in our experience) are not visible in a standard roentgenogram made one year before their first discovery.

II. *Clinical Criteria*

The four important points are the age, sex, presence or absence of thoracic symptoms, and history of recent thoracic tap or surgery. The frequency of primary bronchial carcinoma increases significantly after age 45. It is about five times as frequent in males as in females. In our experience respiratory symptoms have been more commonly associated with an inflammatory lesion than with a primary malignant lesion. Therefore, absence of symptoms favours the possibility of neoplasm. Recent surgery should be noted inasmuch as small intrapulmonary hematomas may follow needling or other procedure and may resemble solitary nodules for some months. Use of oily nose drops should be ascertained, since lipid pneumonia may present as a solitary nodule.

III. *Laboratory Data*

Laboratory examinations such as skin tests and sputum studies are of limited value in the identification of solitary nodules. However, in persons under 40 years of age, they have proved very useful at times. The group we have attempted to utilize or recommend are as follows: skin or complement-fixation tests for tuberculosis, coccidioidomycosis and histoplasmosis; sputum examination for tubercle bacilli and tumour cells. For example, in a male aged 23 with a circumscribed nodule in the middle third of the left lung, the skin test for coccidioidomycosis was strongly positive, and for tuberculosis and histoplasmosis was negative; he had recent domicile in the southwest; his lesion had not been present in a film made one year previously. He was diagnosed as having coccidioma, treated accordingly, and cured.

Sputum or bronchial wash cytological study is rarely positive, except in very large neoplastic nodules.

Three-Step Chart

It has been found useful in practice to complete a "solitary pulmonary nodule chart" in each case under study, because this forces the busy radiologist to record the available pertinent data and to seek the remainder. When the patient is a male of 60 with a roentgen shadow strongly suggestive of neoplasm according to the above criteria, time should not be wasted on laboratory tests. On the other hand, when the patient is a female aged 30, it is permissible to utilize a few days seeking data which may obviate a needless and hazardous surgical procedure.

THREE-STEP CHART: SOLITARY PULMONARY NODULE CHART

Name:		X.R. No.	Date:
1. Radiographic data	Margin Strands Calcium Previous films		
2. Clinical data	Age Sex Symptoms Thoracic surgery		
3. Laboratory data	Tuberculin skin test Coccidioidin skin test Histoplasmin skin test Sputum examination		
Conclusion:			

Of the various factors involved, age is undoubtedly one of the more important, sex and symptoms are quite important, and presence or absence of the opacity in previously taken roentgenograms is of great importance. With experience, the x-ray appearance of the lesion has been of decisive value in many cases, but not in all. As in every other diagnostic procedure, deductions must be made with reasonable judgment. *Attempts to complete preliminary diagnosis on the basis of a single film are to be deplored.*

RESULTS

Utilizing the three-step method, it was possible to classify as presumptively "benign" or "malignant" 106 of 115 consecutive pulmonary nodule lesions. In 9 we were unable to reach a definite conclusion. In the formative period of the study, all cases were operated upon. In the last few years several have been treated by conservative means. Validation of the lesion is therefore established on clinical or associated grounds in some 10 cases.

Of the 68 nodules diagnosed as benign 66 were so verified; in 2 a mistake was made — the nodules proved to be primary malignant tumours.

Of 38 cases diagnosed malignant, 34 were so verified and 4 proved to be benign lesions (one benign tumour, three granulomas).

Of the nine unclassified nodules, five proved to be malignant tumours, and four benign lesions (three granulomas and one benign tumour).

TABLE II.—RESULTS OF THREE-STEP METHOD IN 115 CONSECUTIVE CASES

	Diagnosis by 3-step method	*Diagnosis confirmed*	*Error*
Benign	68	66	2
Malignant	38	34	4
Unclassified	9	..	..

(Diagnostic conclusion reached in 106 of 115 cases; diagnosis correct in 100 cases, or 86%.)

In the entire group of 115 solitary nodules, 74 were benign lesions, and 66 of them were correctly classified by the three-step method (89%). Malignant lesions numbered 41, and 34 of these were so diagnosed (83%).

The benign lesions included the following:

Granuloma, tuberculous or unclassified	51
Granuloma due to coccidioidomycosis	7
Granuloma due to histoplasmosis	3
Infection with abscess	3
Benign tumours: hamartoma	5
adenoma	1
neurofibroma	1
angioma	1
Bronchogenic cyst	2

The malignant lesions included 2 solitary metastatic lesions and 39 primary bronchial carcinomas.

It is to be noted that the identification of the majority of these nodules was surgical, since in the earlier period we did not have sufficient experience with, or confidence in, the method to urge less radical confirmation. However, in the last three years the experience has been such that several lesions identified as benign have been treated by the attending physician as such and their course proved confirmatory.

SUMMARY

A three-step method is described for the preoperative or non-surgical diagnosis of solitary pulmonary nodules.

Using this method in a series of 115 consecutive patients with such nodules, it proved possible to differentiate benign from malignant lesions in almost 90% of cases.

The method is regarded as a useful one for expediting sound surgical intervention in cases diagnosed as malignant, and obviating needless thoracotomy in cases diagnosed as benign. No method, including histological examination, is entirely devoid of error, and therefore this three-step method should be used with sensible discretion in the important problem at hand.

References

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DISINFECTION OF NURSERIES CONTAMINATED WITH STAPHYLOCOCCI*

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In spite of the fact that most hospitals have become alert to the problem of staphylococcal infections, no institution can claim to have solved it completely. The potential danger of severe epidemics remains, and it is only with the utmost care that the serious situation can be avoided. Staphylococcal infections cannot be prevented entirely but they can be held to a minimum.

To those who are concerned with the problem it is becoming increasingly obvious that good housekeeping forms one of the most important parts of any infection control program. Although satisfactory disinfection techniques may be evolved in the laboratory, their practical application is the responsibility of the housekeeping staff. In this hospital the Department of Bacteriology has been fortunate in having the co-operation of an able administrative housekeeper† whose personal interest and efficiency have contributed greatly to the activity of the infections committee.

The following report deals with the disinfection of nurseries, although similar methods are applied to other contaminated areas in the hospital.

Materials

In the selection of a disinfectant many factors must be considered. A germicide which is irritating to the mucous membranes cannot be used, regardless of its efficiency, because of the unpleasant effect on the personnel. The cost of the product must also be taken into account, as well as its ease in handling. Many good disinfectants are prohibitive either because they are too expensive or because they need to be applied in a special rinsing process which increases the cost of labour.

After testing many compounds, a chlorinated phenol in a soap miscible base, o-benzyl-p-chlorophenol (Aseptone*), was selected to be used in all disinfecting procedures. It is efficient from a bacteriological point of view, has a pleasant non-irritating odour, and because it is compatible with soap, it can be used in the routine wash mixture and requires no special application.

The formula for the disinfectant soap mixture is as follows:

Stock solution	
Detergent	36 gal.
Aseptone	9 gal.
Washing solution	
Stock solution	4 oz.
Water (soft)	1 gal.

A special Aseptone mixture is supplied for use as an aerosol.† This consists of o-benzyl-p-chlorophenol, propylene glycol and alcohol.

Method

The obstetrical floor contains three double nurseries, each pair being connected by a single treatment room, and having a total of 47 bassinettes in single cubicles. There is also a separate "suspect" nursery containing 4 to 6 bassinettes. Each nursery is made available for decontamination twice a month. A specially selected team which has been trained by the administrative housekeeper is responsible for the disinfection of all contaminated areas in the hospital. It is most important that the men be moderately intelligent as well as conscientious and that they work under a supervisor who understands the disinfection procedures.

The empty nursery is well sprayed with the Aseptone aerosol mixture and left for 20 minutes. At the end of this time most of the fog has settled on exposed surfaces. The cleaning crew then proceeds to wash the room thoroughly with the Aseptone soap mixture, and the remaining disinfectant in the air is removed by vacuum filtration.‡ The entire contents of the room are washed including the floors and walls. No exposed area is neglected. When the cleaning is completed (in approximately one hour), a slight but pleasant odour persists which tends to assure the nursing staff that the area has been properly disinfected.

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*Rougier, Inc.
†Aseptone Airspray.
‡Electrolux model Z33 with filter.