Radiology in Tumor Localization and Definition

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Radiologic techniques for the diagnosis of cancer are thoroughly understood and well applied. Less so are imaging procedures for the pretreatment localization and definition of disease. In recognition of this situation, the following article reviews the responsibilities of the physician in radiologically defining the primary tumor, as well as nodal and extra-nodal metastases. (Table 1.)

In most instances, tumor visualization is size-limited and location-dependent. Computerized axial tomography, ultrasound, nuclear imaging and newly evolving imaging and recording systems will improve our diagnostic yield. However, more appropriate application of existing techniques, combined with a knowledge of the behavioral characteristics of various tumors and their staging-classification schemes should greatly improve the accuracy of pretreatment tumor definition. Too often, unnecessary examinations, such as radiographic bone surveys for early cervical cancer, are utilized while more appropriate studies, such as lymphography for advanced cervical cancer, are not considered.

Nuclear medicine procedures will only be referred to in general terms, as they complement radiographic studies. Nuclear imaging techniques are described as either indirect or direct. Indirect tumor images, such as routine brain, bone and liver scans are more common. These tumor images result from non-specific changes secondary to the neoplasm. In the liver, the negative image of the tumor is caused only by the mass itself, while in the brain and bone, images are produced by more complex alterations in the host, such as presumed alterations in the "blood-brain barrier" in brain scans. Direct nuclear imaging techniques label some aspect of the tumor, thus allowing it to be visualized. An example is the use of a metabolic agent such as 131I to define a functioning metastatic thyroid cancer. Unfortunately, radiolabeling is non-specific for cancer and is also found in other conditions, such as infection. Both false-positive and false-negative results have limited the application of these procedures.¹

Future improvements in nuclear imaging techniques and the development of tumor-specific radiopharmaceuticals will greatly enhance the role of nuclear imaging in cancer.

Central Nervous System

Computerized axial tomography (CAT) has proven to be an effective, specific and sensitive means of detecting space-occupying lesions of the brain. In fact,
### Table 1.
Radiologic Detection of Metastatic Cancer

| Cancer Sites | Common Metastatic Sites | Follow-up Intervals | Radiographic Follow-up Methods | Comments |
|--------------|-------------------------|---------------------|-------------------------------|----------|
| Brain        | None, local             | 6-12 mo.            | Angio-scan, CAT               | Spread outside CNS rare. |
| Head & Neck  | Local, lung             | 6-12 mo.            | PA and lateral chest          | Squamous cell primary = orderly spread to nodes, mediastinum, lungs. Adenoid cystic = late metastases to lungs. Thyroid = nodular, late (¹³¹I scan). |
| Breast       | Local, lung and bone    | 6 mo.               | PA and lateral chest          | Bone scan or films only with advanced primary, or if symptomatic. |
| Lung         | Widespread              | 3-6 mo.             | PA and lateral chest          | Cell types metastasize in similar fashion except oat cell (disseminated at Dx). |
| Upper GI Tract| Local, lung             | 6-12 mo.            | PA and lateral chest          | Lymphangitic tumor spreads to lungs. |
| Colon        | Liver and lung          | 6-12 mo.            | Liver scan, (chemistries), PA and lateral chest | Nodular pulmonary metastases. |
| Bone         | Lung and bone           | 3-6 mo.             | Stereo PA chest               | Nodular pulmonary metastases. |
| Renal        | Lung                    | 6-12 mo.            | Stereo PA chest               | Nodular pulmonary metastases. |
| Soft part Sarcomas | Lung      | 6 mo.              | Stereo PA chest               | Nodular pulmonary metastases. |
| Lymphomas    | Nodes, lung             | 6 mo.               | PA and lateral chest, lymphangiogram | Non-Hodgkin's lymphoma is disseminated at Dx in the majority of patients. |
| Gyn: Cervix/ uterus | Pelvic nodes, lung(late) | 6-12 mo.   | IVP, PA and lateral chest     | Local pelvic recurrence; lung, nodules. |
| Ovary        | Abdomen, lung (late)    | 6-12 mo.            | IVP, PA and lateral chest     | Ascites, tumor nodules; lung, lymphangitic. |
it has become the method of choice for brain tumor definition. Radionuclide
and CAT scans detect primary and metastatic brain tumors with approximately
the same frequency. Each technique will occasionally detect a lesion missed by
the other. With current CAT systems and routine utilization of contrast-enhanced scans, the need for radionuclide
brain imaging will be decreased markedly. As yet, a size threshold for lesion
detection by CAT has not been established but, when combined with radio-
uclide scans, should approach 100 percent for tumors more than one to two
cm. in diameter. The CAT scan also provides an excellent system for tumor defini-
tion and follow-up, subsequent to treatment.

Head and Neck
Medical imaging procedures for head and neck cancers are generally more ap-
propriate to tumor definition than initial diagnosis. Meticulous pretreatment ra-
diographic technique is necessary to define the volume of a primary tumor in
the sinuses, oral cavity and pharynx. Tomographic, positive contrast and CAT
techniques are applicable here.

For a primary tumor in the naso-
pharynx and sinuses, tomography of the
skull base is essential to define destruc-
tive changes. The excellent detail pro-
vided by newer CAT units may make this task easier. With oral tumors, plain
film search for osseous involvement and its differentiation from the complica-
tions of infection or osteonecrosis can usually be made.

Contrast laryngography is the pro-
dure of choice for a primary laryngeal
lesion, both to define the site of origin
and evaluate its extent. Laryngography
should be done soon after clinical tumor
detection and, ideally, before biopsy.
Plain film examination and tomography both suffer from a lack of specificity and
sensitivity compared with contrast laryngography in primary laryngeal
cancer. However, laryngography is not
as effective a procedure for tumor diag-
nosis. During laryngographic proce-
dures, AP and lateral views during
phonation, quiet breathing, Müller and
Valsalva maneuvers should be taken to
define the bulk of the primary tumor and
accurately assess the subglottic area, the
pyriform sinuses and the mobility of the
vocal cords.

Since the majority of thyroid cancers
are of the papillary-follicular type, ra-
diodine imaging is the cornerstone of
post-treatment follow-up for residual
disease in the neck and for metastatic
tumor definition subsequent to ablation
of residual thyroid tissue by surgery or
131I therapy.

Radiology has little application in es-
stablishing the "N" category of the TNM
system, except for a functional thyroid
cancer. With the thyroid again as the
occasional exception, the lung is the
most frequent site for extranodal metas-
tases. Extrapulmonary metastases are
uncommon, making radiographic or ra-
dionuclide surveys unnecessary, espe-
cially in the pretreatment assessment of
head and neck cancers other than the
thyroid.

Breast
Film mammography and xeroradiog-
raphy in concert with clinical examina-
tion can detect and define a primary breast cancer in over 95 percent of pa-
patients. When radiographic abnormalities
are the only indications of cancer, speci-
men radiography can aid the biopsy pro-
ceedure. Thermography has an unaccept-
ably high false-positive rate and should
not be used alone as a screening-diag-
nostic technique. It may even be of lim-
ited value when combined with film
mammography.3

Radiographic techniques have little
use or accuracy in detecting nodal dis-
 ease. Pretreatment assessment of extran-
odal metastases should, therefore, be
directed to the lung and skeleton. Ra-
A middle-aged male with an epidermoid carcinoma, left lung T3 N2. The T3 lesion is more than three cm. in diameter, and extends to within two cm. of the carina with subcarinal and bilateral mediastinal adenopathy (arrows).

This task is made more difficult, however, when surrounding non-tumor complications, such as obstructive pneumonia and atelectasis are associated with a central obstructing lesion. CAT techniques may well play a significant role in improving present tumor definition capabilities. Special radiographic procedures have limited value in further defining the primary. Table 2 outlines a general approach to the radiographic evaluation of the TNM categories of lung cancer.

An understanding of tumor histology helps guide the search for mediastinal and extrathoracic disease. Small cell anaplastic lesions usually are disseminated at diagnosis, hence liver, bone and brain scans should have a higher yield. On the other hand, radiographic bone surveys have no place in the pretreatment evaluation.
assessment of lung cancer. Nodal disease in the mediastinum can be difficult to define, a task the CAT scanner may facilitate. At present, fluoroscopy, esophograms and tomograms are most useful to map the mediastinum.

Gastrointestinal Tract
The esophagus and pancreas share the problem of lung cancer: the inability to detect primary cancer at an early enough stage, so that successful treatment is possible. Identification of the high-risk patient for esophageal cancer and subsequent careful radiographic examination should improve the efficiency of detection. CAT scanning has already shown its ability to more accurately locate and define tumors of the pancreas. However, its impact in terms of greater survival will probably not be great, as CAT scanning is an impractical screening tool and is only useful in symptomatic, advanced pancreatic cancer. The radionuclide pancreatic scan is valuable in a negative sense; a normal scan virtually excludes the possibility of major pancreatic pathology.

Present double contrast radiographic studies of the gastrointestinal tract complement endoscopic approaches and appear adequate to define a primary tumor. Angiographic methods have been disappointing, both with respect to their diagnostic sensitivity and their specificity for abdominal neoplasms other than those outside the peritoneal cavity. In addition, it is often difficult to differentiate primary liver cancer from hepatic metastases by angiography. Certainly, CAT scanning will aid in the definition of hepatic tumors with less morbidity but, doubtfully, more accuracy and specificity.

Radiography can seldom define nodal disease from a gastrointestinal primary tumor. Metastatic surveys, therefore, are focused on the liver and lung. Ra-
The pattern of pulmonary metastases depends on the site of origin of the primary tumor. Gastric and pancreatic cancers are associated with lymphangitic patterns, whereas a colonic primary is characterized by nodular metastatic pulmonary lesions, with poorly defined margins. Comparative chest radiographs are essential to detect the subtle changes of pulmonary metastases, after abdominal extension has been recognized, regionally or to the liver.

**Genitourinary Tract**

The pyelogram has well-established sensitivity in the detection of a renal parenchymal mass, but it lacks specificity. Ultrasound, CAT and angiographic techniques, used with discretion, permit the preoperative diagnosis of nearly 100 percent of renal parenchymal primary cancers. Transitional cell tumors and metastatic renal lesions are more difficult to recognize. Adrenal and retroperitoneal tumors often are more challenging to define radiographically, a problem both ultrasound and CAT are essential to resolve.

Primary cancers of the male and female reproductive organs are seldom defined by radiographic methods. An exception includes a cystic ovarian mass, in which ultrasound is useful.

However, lymphography is an underutilized procedure to define nodal metastases in advanced cervical, prostatic and testicular cancers.7,8 Lymphography is also useful in the pretreatment evaluation of ovarian cancer, as well as in follow-up, but seldom is systematically applied. If the study is “positive,” a 90 percent accuracy can be expected; negative studies are associated with relatively high false-negative rates (20 to 25 percent).9 Because of the procedure’s inability to detect small foci of disease, this limitation applies to lymphography for all non-lymphomatous tumors.

Radiographic skeletal surveys have no place in the pretreatment evaluation of gynecologic primary cancer. However, local bone extension usually is evident on conventional films of the abdomen. Distant bone metastases are extremely uncommon, since local pelvic and abdominal extension is the rule with these tumors.

**Bone**

Radiographic methods have remained the most effective means of detecting primary bone tumors as well as an essential study in their final classification. Low kilovoltage, high milliamperage radiographs taken with detail screens must include both bone and soft tissue. Tomography aids in treatment planning by outlining the lesion and its proximal extent. Xeroradiography provides dramatic soft tissue and bone detail on a single film and is often used.

No diagnosis of a primary bone tumor is secure until the skeleton has been searched for other similar lesions. The screening process is probably best done with a radionuclide bone scan. X-rays of abnormal scan sites are necessary to exclude a non-neoplastic etiology.

Stereoscopic chest X-rays provide a simple, inexpensive method of detecting pulmonary metastases and forming a baseline. Full chest tomography should be reserved for the doubtful, questionable patient, or used preoperatively in those individuals programmed for radical treatment. In our experience, full chest tomography will rarely reveal pulmonary metastases that were not demon-
Fig. 2. (A) Hodgkin’s lymphoma with extensive para-aortic node replacement on lymphangiography. (B) The transverse and (C) longitudinal axis ultrasound scans show the extensive echo-free, involved, para-aortic nodes.

strated on stereo chest radiographs.

Lymphoproliferative Neoplasms

A greater understanding of the behavior of the many clinical diseases represented under this heading would significantly enhance the appropriate application of radiologic procedures for their identification and localization. As an example, pulmonary parenchymal involvement at diagnosis is extremely uncommon in any of these neoplasms. In the leukemias, pulmonary involvement can seldom be identified on chest radiographs, since leukemic infiltrates generally occur late in the course of the disease and are microscopic. Most pulmonary abnormalities in the leukemias, therefore, are secondary to infection, heart failure, alveolar hemorrhage or treatment complications. In the Hodgkin’s lymphomas, pulmonary parenchymal involvement virtually always follows hilar-mediastinal disease. Pulmonary involvement in a patient with a known Hodgkin’s lymphoma should be presumed to be non-tumor related, unless the history reveals previous radiation
therapy or a mediastinal tumor. Similarly, of the lymphomas, gastrointestinal and bone involvement is least common in Hodgkin's disease.10

Lymphangiography plays a vital role in the staging and follow-up of all lymphomas. Here again, its value lies in the negative study, as a positive study may be non-specific. In the non-Hodgkin's lymphomas, the lymphangiogram has a
less significant function, since more of these lesions are disseminated at diagnosis. Bulky, clinically obvious lymphadenopathy can usually be easily mapped by ultrasound scanning, which is also utilized in treatment planning both initially and on follow-up. When a bulky tumor has enlarged the nodes, they tend to be trans-sonic or echo-free, resembling a cyst on ultrasound scans. (Figs. 2A., B., C.) Radionuclide scans have not proven useful in identifying a tumor that was not evident clinically or radiographically.

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The Art of Medicine

Medicine is still not an exact science. The mathematical precision of foretelling the coming and going of an eclipse is lacking in determining the onset of a crisis in many illnesses, even in lobar pneumonia with all our very effective antibiotics. Medicine is still very much an art, and often still more of an art than a science. This is a very important realization and must take into account the importance of the abstract, and the less exact, immeasurable emotional and psychological aspects of medical care. ——Alfred A. Angrist: New challenges for the medical graduate. New York State J. Med. 71:2265, 1971.