THE GAMUT APPROACH TO SCINTIGRAM INTERPRETATION—DIAGNOSTIC AID AND TEACHING METHOD

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A Gamut is defined as a complete list of anything. As utilized here, it indicates a complete list of the possible causes of a particular scintigram finding. The procedure for developing a Gamut is discussed, and its use as a tool for instructing residents in nuclear medicine is described. Sample Gamuts are presented and the Gamut approach to scintigram differential diagnosis is described.

Training a resident or fellow as a nuclear medicine physician, as opposed to training a radiologist, internist, or pathologist with just an interest in nuclear medicine, presents many challenges. Within the University of Cincinnati Medical Center, the Radioisotope Laboratory acts as a consultative service. We assist the primary physician in choosing the appropriate procedure, evaluate each patient prior to performing the study, and, in evaluating the scintigram, attempt to answer specifically the clinician's question.

Because of this prior consultation, the radiology or pathology resident cannot view the brain scintigram, for example, as an isolated test. He must understand the scheme of the neurologic workup. He may suggest a radioisotope cerebral angiogram, a radioisotope cisternograph, or delayed static images. He must also know the limitations of each procedure so that he can save time, money, and effort by performing only appropriate examinations.

The internist involved in nuclear imaging must become familiar with the three-dimensional aspects of interpretation, which are second nature to the radiologist. He must learn more about the indications and contraindications of the radiologic procedures that are complementary to nuclear medicine studies, since he will be in a position to recommend those examinations.

GAMUT APPROACH

The use of the Gamut approach to scintigram interpretation provides one way to integrate these specialties. A Gamut, as utilized here, indicates a complete list of the possible causes of a particular scintigram finding.

As an aid to differential diagnosis this approach has been used for many years in the Department of Radiology at the Cincinnati General Hospital by Dr. Benjamin Felson, and at the Armed Forces Institute of Pathology by Dr. Maurice Reeder (*1*). It rests on the following triangulation concept described by Dr. Reeder (here, scintigram has been substituted for roentgenograph, nuclear medicine physician for radiologist, and the examples have been made pertinent to nuclear medicine):

1. Successful scintigram interpretation begins with a detailed analysis of all the indications of disturbed structure and pathophysiology seen on the scintigram.
2. The nuclear medicine physician can usually fit the visualized abnormalities into a specific pattern of disturbed function, such as wedge-shaped perfusion defect in a lung scintigram, or multiple ill-defined areas of increased activity in a brain scintigram. For each pattern there is a specific Gamut or comprehensive list of possibilities.
3. This list can be narrowed to a few reasonable possibilities for a given patient, based on age, symptoms, and a knowledge of pertinent clinical and laboratory data (*2*).

Developing each Gamut and its continual updating provide a broad learning experience. Four

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TABLE 1. UNILATERAL ABSENT PERFUSION OF THE LUNG*

Common

Bronchogenic carcinoma (3)

Less common

1. Pulmonary embolism (3)
2. Parenchymal/pleural disease, severe (3)
3. Congenital heart disease, postsurgery (3)
4. Postpneumonectomy (3)

Rare

1. Stenosis of the pulmonary artery, agenesis or hypoplasia of the lung and/or pulmonary artery (4,5)
2. Endobronchial foreign body (6,7)
3. Hyperlucent lung syndrome (3)
4. Pulmonary veno-occlusive disease (8)
5. Bronchial adenoma (9)

* Compiled by T. Tomsick, December 1974.

TABLE 2. SINGLE FOCAL AREA OF DECREASED HEPATIC UPTAKE OF RADIOCOLLOID*

Common

1. Metastatic neoplasm (10,11)
2. Primary hepatic neoplasm (12)
3. Pyogenic abscess (13)
4. Trauma (14)
5. False positive (15–17) (See Gamut of false positives)

Less common

1. Cirrhosis (18)
2. Lymphoma (10,11)
3. Postradiotherapy (13)
4. Cyst
   - Simple (13)
   - Hydatid (12)
5. Abscess
   - Tuberculous (11)
   - Amebic (13)
   - Actinomycotic (12)
6. Chronic nonspecific inflammatory changes (19)

Rare

1. Hemangioma (11,20)
2. Focal nodular hyperplasia (21)
3. Hepatic vein thrombosis (22)
4. Hyperlipoproteinemia (23)
5. Amyloidosis (24)
6. Viral hepatitis (25)
7. Scleroderma (17)

* Compiled by D. P. Colley, November 1974.

Gamuts recently compiled in our department are presented in Tables 1–4. These were done by second-year radiology residents (TT, DC) and first-year nuclear medicine fellows with backgrounds in internal medicine (MF, ZC).

Beginning with one of the major nuclear medicine textbooks, a review-type journal, or a previous "Gamut," the resident obtains an overview of the subject. The major tasks of determining which lesions are "common" and of documenting those entities for which only a few cases have been reported requires a determined review of the literature. This review serves several functions. The resident becomes more familiar with the sources of nuclear medicine information. The internist learns about such journals as *The American Journal of Roentgenology, Radiation Therapy, and Nuclear Medicine, Clinical Radiology*, and *Radiology*, to name a few. Similarly the radiologist discovers that such subspecialty journals as *Gastroenterology* or *The American Journal of Surgery* contain articles pertaining to nuclear medicine. Importantly, articles in such clinically oriented journals tend to focus more on the usefulness of nuclear medicine procedures, rather than on the technical aspects of the studies, which are covered

TABLE 3. SINGLE LOCALIZED AREA OF INCREASED RADIONUCLIDE UPTAKE ON BONE SCAN*

Common

1. Metastatic tumor (lung, breast, prostate) (26,27)
2. Post-thoracotomy/surgery scar (26,28)
3. Vertebral body compression fracture (26)
4. Normal variants (shoulder, sternum) (29)

Less common

1. Metastatic tumor (cervix, neuroblastoma in children) (27,30)
2. Primary bone tumor (Ewing's sarcoma, osteosarcoma, osteochondroma) (26,31)
3. Lymphoma (26,27)
4. Monarticular degenerative disease (26)
5. Trauma (fractures other than vertebral body, biopsy site, prosthesis site) (26)
6. Osteomyelitis, pyogenic (26)
7. Periodontal abscess (32) and post-tooth extraction
8. Paget's disease (26,27)

Rare

1. Metastatic tumor (thyroid, renal, melanoma, pancreas, other gastrointestinal) (27)
2. Primary bone tumor (fibrosarcoma, chondrosarcoma, giant-cell tumor, fibrous dysplasia, enchondroma, osteoid osteoma, bone cyst, hemangioma) (26,32–35)
3. Multiple myeloma (27)
4. Aseptic necrosis (33)
5. Osteitis pubis (33)
6. Osteomyelitis, TB (26,36), coccidiomycosis (27)
7. Extraskeletal calcified and noncalcified tissue uptake: breast carcinoma (29,34), neuroblastoma (37,38), neurofibroma (39), brain metastasis from lung carcinoma (40), cecal/rectal carcinoma (34), nasopharyngeal carcinoma (34), fibrosarcoma (35), soft-tissue abscess (40), brain infarct (41), myocardial infarct and other areas of tissue necrosis, Hodgkin's disease involving spleen (42), leukemic infiltrates (35), post-traumatic calcifying hematoma (35), myositis ossificans (43), calcific tendinitis (33), thrombophlebitis (27)
8. Gout (26)
9. Periostitis (31)
10. Meningioma (44)

* Compiled by M. Fernandez, January 1974.

TABLE 4. SINGLE DISCRETE AREA OF DECREASED UPTAKE IN STATIC BRAIN SCAN*

Less common

1. Complete occlusion of one internal carotid artery (diffuse decrease) (45)
2. Thrombosis of superior sagittal sinus (46)
3. Metallic plates, postneurosurgery
4. Lateral ventricle, grossly enlarged (47)

Rare

1. Extradural hematoma (48)
2. Arachnoid cyst (49)
3. Porencephalic cyst (50)
4. Cystic hygroma (50)

* Compiled by Z. Catz, December 1974.

adequately in the nuclear medicine specialty journals such as the *Journal of Nuclear Medicine.*

Each Gamut, in a preliminary form, is reviewed at one of our morning conferences, at which time suggestions for additions or deletions are made. As noted in the sample Gamuts, each lesion that has been known to occur with the particular scintigram finding is referenced. Those that are not referenced represent our laboratory's experience. An entity is arbitrarily designated as "commonly seen" if it has been encountered with recognizable frequency in our laboratory. Hydatid cyst of the liver, for example, which is common worldwide but not in Cincinnati, is therefore classified as "less common." A lesion may be "less commonly seen" or "rare" for several reasons. First, it may indeed be rare, such as an amyloid mass in the liver. Second, a scintigram may rarely be done for that particular condition, such as a bone scintigram for gout. In still other cases, the specific scintigram finding may be an uncommon presentation of a common disease, such as monarticular involvement in degenerative arthritis.

CONCLUSION

A file of Gamuts or "Gamut Book" is kept in the readout room, to be consulted both when studies are scheduled and when they are reported. The resident who has compiled the Gamut obtains a great deal of satisfaction from becoming an "expert" in a segment of nuclear medicine. The remainder of the department benefits by having an up-to-date literature review available in a clinically useful format.

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