Experience with Mammography in a Tumor Institution

Evaluation of 1,000 Studies[1]

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SOFT-TISSUE roentgenography of the breast is not new. In the American literature, Leborgne (4) of Uruguay described the technic of examination and the rogentenographic appearance of various mammary tumors. Warren (5) of the United States in 1929 reported on 119 cases, 58 of which were malignant. Interpretative errors were made in but 8 cases, 4 being in the malignant group. He stated: "In many of the cases, there was no unanimity of opinion in the preoperative clinical diagnosis. Several opinions were often held as to the presence of malignant or benign tumors in each case. The opinion from the roentgenogram, on the other hand, was often very definite and, most frequently, correct." Since Warren's publication an occasional enthusiastic proponent of this method of examination has appeared. However, as of the date of this study, no satisfactory statistical analysis of consecutive mammograms in patients with adequate follow-up has appeared in the American literature.

MATERIAL

One thousand consecutive x-ray examinations of the breast were performed at the M. D. Anderson Hospital and Tumor Institute in the period from May 1956 to May 1959. Adequate follow-up to date has been available on all except 2 patients. These were excluded from the series as both were examined in the terminal stage of malignant lymphoma, and neither biopsy nor autopsy was obtained. Six hundred and thirty-four patients were examined. For simplicity of presentation of results, each breast was considered a separate study. Frequently there was a lesion, benign or malignant, on each side, possibly with only 1 correctly diagnosed; or the patient may have had a previous mastectomy, leaving only one breast for study.

Not all patients admitted to the Hospital's breast service were referred for mammography. During the three-year period 1,253 new patients with lesions subsequently proved by biopsy were seen at that clinic, and of these, 956 had malignant and 297 had benign lesions. Cases of a questionable or palpable nodule in the breast, an inverted nipple, or nipple discharge were referred for mammography. Occasionally breasts were normal to palpation even though there was undifferentiated carcinoma in the axillary nodes or osseous lesions resembling metastatic carcinoma of the breast. Breasts containing clinically obvious carcinoma or with a known diagnosis of carcinoma following recent biopsy were not studied. The opposite breast was examined when such a patient was referred for mammography, however. If the result of the previous biopsy was not stated on the request for roentgenography, both breasts were radiographed.

ROENTGENOGRAPHIC TECHNIC

Positioning of the patient is illustrated in Figures 1–3. One roentgenogram of the axilla is obtained and two of the breast, in 2 planes at right angles. These have resulted in good delineation of the quadrants, ease in positioning, and patient comfort with consequent cooperation. The entire breast is positioned on a pliable cardboard holder which may be placed to follow the contour of the chest wall in the oblique position, thus covering the smallest gland. "Kodak Industrial M" film is used. The range of technical factors is shown in Table I. Usually the only variable is the distance necessary to include the entire breast on the roentgenogram. In general, 26 kv

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Fig. 1. Positioning for the cranio-caudad view. Identification marker is kept on the axillary side of breast for localization of the mammary quadrant.
Fig. 2. Oblique or lateral position. The cardboard film-holder is supported on a small wood block.
Fig. 3. Axillary view. The central beam is centered to the apex of the axilla and also parallel to the retromammary space. This arm position provides maximum visualization of the axilla as it reduces the number of skin folds without superimposition of the scapula. Factors: 54 kv, 300 ma, 40 inches, three and a half seconds; in obese patients the distance is reduced to 30 in.

TABLE I: RANGE OF TECHNICAL FACTORS USED TO PRODUCE ROENTGENOGRAMS OF THE BREAST

Age Group, Breast Type	Technical Factors
I. Menopausal, average consistency	
Small	
Cranio-caudad projection	300 ma, 22 kv, 30 in., 6 sec.
Oblique projection	300 ma, 24 kv, 30 in., 6 sec.
Medium	
Cranio-caudad projection	300 ma, 26 kv, 36 in., 6 sec.
Oblique projection	300 ma, 28 kv, 36 in., 6 sec.
Large	
Cranio-caudad projection	300 ma, 26 kv, 40 in., 6 sec.
Oblique projection	300 ma, 28 kv, 40 in., 6 sec.
II. Postmenopausal	Average 2–4 kv less; if flabby and flat, 5 sec.
III. Premenopausal, 30- to 45-year age group	Same as menopausal if only residual glandular tissue; 2–4 kv added with firmer breasts
IV. Virginal type	Same as premenopausal firm breast, but because of usually smaller size, 26 to 30 in. covers breast; 32–34 kv occasionally required
V. Dense area	Distance reduced to 20 to 22 in.

for the cranio-caudad projection and 28 kv for the oblique view, with 300 ma and six seconds, will suffice. The decreased distance for the smaller breasts adds sufficient mas to penetrate the denser glands; the larger breasts containing more fat are less dense, and require less mas. Only inherent tube filtration is used.

This technic has been productive of satisfactory roentgenograms in the hands of both student and staff technicians. Repeat examinations are rare. In practice the examination is no more difficult than routine chest studies and the time involved is comparable to that of a routine cervical spine study.

Neither the large focal spot nor the long exposure causes appreciable loss of detail. Use of a single fine-grain intensifying screen preserves most of the detail but with the addition of a second fine-grain screen soft-tissue detail is sacrificed. This is in contrast to the technics of higher kilvoltage, fast intensifying screens, and coarse-grain film advocated in the American literature (1, 3).

At these kilovoltage ranges, true mas was not obtained due to electron fog at the tube filament. The usual diagnostic x-ray machine does not have compensatory filament voltage regulation below 40 kv. Kilovoltage settings below 30 kv actually produce film characteristics more in keeping with the changes in mas than with the quality of the x-rays reaching the film.

The amount of radiation to the eye, skin, or gonads could not be calculated; actual measurements had to be made. In the

cranio-caudad position the film-holder was placed over a lead shield to protect against possible gonadal radiation. Patient exposure was found to be negligible.

The aluminum wedge may be used to transfer technical factors from one x-ray unit to another. At a distance of 36 inches, and with employment of a cone, type "M" film in a cardboard holder, and 300 ma at six seconds, the kilovoltage is varied until 15 mm. of aluminum is just faintly penetrated. This kilovoltage setting may then be used as the average and changed accordingly.

STATISTICAL METHODS

When it was decided to set up a technic for soft-tissue roentgenography of the breast in our department we felt we should be as objective as possible in the interpretation of the examination and rely entirely upon the roentgenograms without benefit of history or physical findings. The report of each study would include the absence or presence of a lesion and an opinion as to its benignity or malignancy. The diagnosis would be designated by a specific code symbol so that in review no confusion would arise as to the original conclusion. In such a system, there would be no provision for indeterminate studies. The single most important diagnosis was used in tabulation of the results even though more than one pathologic entity was present in the same breast.

All patients having mammography were examined in the breast clinic and most of them have been followed by periodic examinations there. A few, referred for consultation only, had follow-up reports from the referring physicians in their charts, giving either the final pathologic diagnosis or the results of periodic examinations. The clinical diagnosis of fibrocystic disease has been substantiated by aspiration of a cyst in many instances. Papanicolaou studies were routinely made on all patients with nipple discharge.

The follow-up span on all patients varied from six months to three and a half years, including the 361 whose examinations were read as negative. In none of these cases did breast carcinoma subsequently develop within the follow-up period.

The pathologist's most recent opinion on the breast biopsy tissue, the radical mastectomy specimen, or the postmortem findings was used as the diagnosis in each case. In the absence of a biopsy, those lesions diagnosed as benign have been considered verified by typical roentgenologic and physical findings which have remained constant on follow-up examinations.

ROENTGEN DIAGNOSIS

The important diagnostic signs in soft-tissue roentgenography of the breast have been lucidly described by Leborgne (4). He reported calcification in malignant mammary neoplasms and described "scattering . . . of innumerable punctate calcifications resembling fine grains of salt . . . . in and surrounding the nodule."

These flecks, referred to as calcifications from their appearance on the roentgenograms, do not all take calcium stains, and may be partly due to detritus in the tumor. The percentage of cases in which they were demonstrated was, in part, proportional to the quality of the roentgenogram. Calcium or not, their presence is practically pathognomonic of carcinoma, and they were observed in 118 of the 245 cases of carcinoma in our series. Coarser and denser types of calcification were found only in benign conditions such as fibroadenoma, plasma-cell mastitis, calcifying cysts, or arteriosclerosis.

The benign breast masses were homogeneously dense, rounded or smoothly lobulated, and surrounded by a thin radiolucent layer of fat. They pushed normal tissue aside and produced only local changes. The malignant tumors were denser in the center, had irregular spiculated borders, invaded nearby tissue, and were usually associated with some secondary changes in the breast: localized or diffuse skin thickening, nipple retraction venous engorgement, or involvement of axillary nodes. Diffuse thickening of the skin was a reliable sign of carcinoma.

TABLE II: DIAGNOSES IN 1,000 CONSECUTIVE MAMMOGRAPHIC STUDIES AS REPORTED AND CODED FROM MAY 1956 TO MAY 1959*
("Clinically negative" indicates breasts normal to palpation)

	Total	Coded as Benign	Coded as Negative	Coded as Malignant	Clinically Negative
Malignant lesion	245	0	7	238	19
Benign lesion; biopsy	182	162	0	20	0
No lesion; biopsy	4	0	4	0	0
Benign lesion; no biopsy	248	248	0	0	...
No lesion; no biopsy	321	0	321	0	321

* This is primarily a statistical review. Since preservation of adequate detail is difficult, no reproductions of roentgenograms are included.

RESULTS

The 1,000 studies were grouped as shown in Table II. The 7 cases of malignant disease coded as negative included 5 patients whose tumor was removed at the time of biopsy prior to admission, with no residual carcinoma being found in the postirradiated radical mastectomy specimen; 1 patient with a tumor in the tail of the breast not demonstrated on the roentgenograms as this was prior to the use of the axillary view; 1 patient with a small parasternal carcinoma that was not projected on the roentgenograms. Considering only the malignant lesions, the definite error in diagnosis by roentgenography was only 2 out of 240, or 0.83 per cent. Malignant tumors were found in 19 breasts clinically considered to be negative.

The benign lesions were diagnosed as indicated in Table III. Five small fibroadenomas in fibrocystic disease were overlooked; these were considered errors in diagnosis, with fibroadenoma used as the primary diagnosis.

DIFFICULTIES, SOURCES OF ERROR, OBSERVATIONS

Roentgenographic technics for soft-tissue study of most areas of the body are critical. This is not true of the breast where contrast of fat and surrounding structures ex-

TABLE III: FREQUENCY OF THE VARIOUS BENIGN CONDITIONS ENCOUNTERED IN 1,000 MAMMOGRAMS FROM MAY 1956 to MAY 1959, TOGETHER WITH THEIR DIAGNOSIS BY MAMMOGRAPHY AND THE LESIONS MORE COMMONLY CONFUSED WITH CARCINOMA

		Total	Correct X-Ray Diagnosis	Coded as Malignant
Benign lesions with biopsy	Fibrocystic disease	102	99	3
	Fibroadenoma*	36	30	1
	Abscess	16	8	8
	Sclerosing adenosis	9	5	4
	Dilated ducts	4	4	0
	Intraductal papilloma	4	2	2
	Benign fibrosis	2	1	1
	Sebaceous cyst	2	2	0
	Cystosarcoma phylloides	3	3	0
	Scleroderma morphea	1	1	0
	Ectopic breast	1	1	0
	Granulomatous tissue	1	0	1
	Granular-cell myoblastoma	1	1	0
Benign lesions without biopsy	Fibrocystic disease	240	240	..
	Plasma-cell mastitis	4	4	..
	Fibroadenoma	4	4	..
TOTAL		430	405	20

* Five fibroadenomas in fibrocystic disease were overlooked.

ists and the paramount aim is detail rather than contrast. There is, however, variability of contrast due to factors of age, size of breast, state of nutrition, pregnancy, lactation, time in menstrual cycle, and the wide range of other normal physiological cyclic changes as well as abnormal processes.

In late pregnancy or lactation, or in the larger and denser virginal type of breast, the roentgenograms tend to be of poorer quality due to the higher kilovoltage required for penetration. For a diagnosis of carcinoma in these dense breasts, the tumor must be large or secondary signs of malignant disease must be present. Although not encountered in this study, a small carcinoma may be overlooked under such circumstances.

The roentgenogram must be obtained with the nipple in profile, otherwise nipple retraction cannot be evaluated.

The false positives, benign processes called malignant, were the greatest source of error in this series. These lesions included abscesses, infected cysts, or fibrocystic disease associated with marked sclerosing adenosis and/or ductal hyperplasia. In a review of these cases, the presence of carcinoma could not be definitely excluded by roentgenography. These are the lesions that would comprise the indeterminate group and, unfortunately, they were also considered malignant clinically; in at least 2 cases biopsies were performed three times.

Another difficulty encountered with fibrocystic disease, as already indicated, was the presence of a small fibroadenoma that was overlooked or considered a part of the fibrocystic process. This was an incidental finding at biopsy. Dilated ducts and intraductal papillomas were frequently similar in appearance; however, the treatment was the same: local excision to control bleeding. The single case of scleroderma morphea was reported merely as benign localized skin thickening, and a granular-cell myoblastoma was also coded only as a benign lesion. Sebaceous or intradermal cysts were readily identified by their relationship to the skin; in accessible areas nevi were clearly shown without extension into the subcutaneous fat.

No comparison could be made with palpatory diagnosis as the clinicians frequently disagreed as to the diagnosis or withheld it with the simple remark "biopsy, frozen section, and, if positive, radical mastectomy." However, subjection of a patient to general anesthesia for diagnosis indicated a strong clinical impression of malignancy.

No attempt was made to record the incidence of primary lesions in both breasts since metastasis *versus* second primary is a difficult problem. The first case of metastatic melanoma to the breast was a single lesion and was coded as carcinoma; however, the second case with multiple lesions in both breasts was recognized and correctly diagnosed as metastatic disease in a patient known to have melanoma. Mucinous adenocarcinoma, although not as aggressive-appearing as other malignant tumors, revealed sufficient changes for a diagnosis of carcinoma. Two cases of cystosarcoma phylloides were coded malignant purely on the basis of size, that being the only difference in appearance from the fibroadenoma or "giant fibroadenoma." Three other cases of cystosarcoma phylloides were coded as benign. The liberty was taken to leave these lesions as such in the tables since the pathologic diagnosis was on the basis of cell morphology rather than invasiveness of the tumor.

Postoperative changes following a biopsy for benign disease vaguely resembled localized carcinoma, without calcification or definite secondary signs of malignancy. In the absence of infectious complications, the mammogram reverted to a normal appearance in seven to ten days. Although many patients dated the onset of a breast nodule from trauma, no calcifying hematoma was encountered.

Usually in the breast with a previous biopsy for carcinoma, residual tumor or secondary signs of cancer were present and the diagnosis of carcinoma was readily made. The mammograms were obtained two to four weeks following the biopsy. The 5 cases with previous tumorectomy and normal mammograms were not considered unusual, however, as in these early lesions, following biopsy, the radical mastectomy specimen is often negative for residual carcinoma. These 5 patients did receive preoperative irradiation.

Of 4 cases of Paget's disease of the nipple, the underlying carcinoma was not detected clinically in 3, but was diagnosed by x-ray examination in all. Although the masses were not palpable, they could not be included with the unsuspected lesions, since the nipple changes reflected the presence of carcinoma clinically. In 1 of these cases, the nipple changes—slight elevation of 1 to 2 mm. and localized discoloration—were not roentgenographically apparent.

The smallest carcinoma demonstrated by roentgen rays was 8 mm. in diameter on sectioning. The presence of stippled cal-

cification led to the diagnosis. In the same breast the existence of a 4-mm. uncalcified nodule in a background of sclerosing adenosis was appreciated, although its malignant character was not. Small carcinomas in sclerosing adenosis were detected by the presence of calcifications; without such evidence, early malignant change cannot be recognized. With demonstrable calcification, the radiologist may be more definite than the surgeon in deciding which nodule should be biopsied or than the pathologist in deciding the question of malignancy *versus* benignity.

The demonstration of axillary nodes by roentgenography has some significance, but their finding is not a diagnostic criterion of malignancy. In 108 cases nonirradiated radical mastectomy specimens were available for pathologic study; axillary nodes were demonstrated by roentgen rays and found to be carcinomatous upon histopathologic study in 88. In 15 other cases microscopic carcinomas which had not been reported were present in axillary nodes, nearly all being less than 1 cm. in diameter. In 5 cases, however, noncarcinomatous nodes had been noted on the roentgenogram.

Despite these difficulties, the average study was simply obtained and readily interpreted. This is contrary to the views of the European authors who have stressed meticulous attention to technical details and special interpretative skills.

DISCUSSION

Soft-tissue roentgenography of the breast can be definitive in the diagnosis of malignant, benign, and normal conditions. Provision must be made for indeterminate studies and is just as necessary and valid for the radiologist as for the pathologist. Clinical judgment is mandatory but the typical carcinoma on a roentgenogram should not be ignored. The time-honored approach of palpation of a breast lesion followed by a decision to observe or prepare the patient for immediate radical mastectomy is necessary and well appreciated. While roentgenography has not established the absolute preoperative diagnosis, its use and refinement should substantially reduce the preoperative diagnostic errors. At times the radiologist may express an opinion contrary to that of the surgeon and on occasion may find it necessary to challenge the pathologist's interpretation of a breast lesion.

In this group of patients, were mammography used as a guide to definitive treatment, no carcinoma would have been overlooked except the 2 not projected onto the films. (At the time of roentgenography, if the location of the palpable nodule in the breast is known, such errors should be preventable.) One hundred and sixty-six general anesthesias would have been avoided and only 20 patients with benign disease would have been prepared for radical mastectomy. It could not be determined in the review of numerous other benign lesions whether the radiologist's report influenced the clinical decision to omit biopsy. In no instance where a lesion was described on the x-ray report was the patient found to have a normal breast.

CONCLUSIONS

The palpatory method of detection and diagnosis of breast lesions is inaccurate even in an institution where a limited number of clinicians evaluate all patients attending the breast clinic, numbering 2,430 yearly. Soft-tissue roentgenography of the breast can reduce the error of preoperative diagnosis and reveal a number of unsuspected lesions. In addition, it can obviate a significant number of general anesthesias now administered for diagnostic purposes. Experience has shown mammography to be a simple method of demonstration of a breast lesion with a high accuracy in prediction of its type. Analysis of the value of soft-tissue roentgenography in our institution has indicated its reliability as a diagnostic tool.

SUMMARY

1. The roentgenographic interpretations, without benefit of history or clinical

findings, of 1,000 consecutive soft-tissue examinations of the breast are given.

2. A simple radiographic technic, based on changing the one variable of distance, is explained.

3. With roentgenograms of sufficient detail, any radiologist with the average physician's knowledge of the anatomy and pathological processes of the breast can diagnose breast lesions with a high degree of accuracy.

4. Experience with this simple examination in our institution has indicated its reliability as a diagnostic tool, with an error of less than 1 per cent in malignant disease.

REFERENCES

1. GERSHON-COHEN, J., AND INGLEBY, H.: Carcinoma of the Breast: Roentgenographic Technic and Diagnostic Criteria. Radiology **60**: 68–76, January 1953.

2. GROS, C.-M., AND SIGRIST, R.: Radiography of the Breast. [In] Gynecologic Radiography, by J. Dalsace and J. Garcia-Caldéron. New York, Paul B. Hoeber, Inc., 1959, Chapter 22.

3. LAME, E. L., AND PENDERGRASS, E. R.: Addition to Technic of Simple Breast Roentgenography. Radiology **48**: 266–268, March 1947.

4. LEBORGNE, R.: Diagnosis of Tumors of the Breast by Simple Roentgenography: Calcifications in Carcinomas. Am. J. Roentgenol. **65**: 1–11, January 1951.

5. WARREN, S. L.: Roentgenologic Study of the Breast. Am. J. Roentgenol. **24**: 113–124, August 1930.

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SUMMARIO IN INTERLINGUA

Experientias con Mammographia in un Institution pro Tumores

Mille consecutive roentgeno-examines del mamma esseva effectuate in 634 patientes inter maio 1956 e maio 1959. Le serie non include casos de obvie carcinoma o de carcinoma cognoscite per recente biopsias.

Un roentgnogramma esseva obtenite ab le axilla e 3 ab le mamma, in 2 planos a angulo recte. Un dispersion de innumerabile punctos de calcification, resimilante granos fin de sal, in e circum un nodulo tumoric indica malignitate. Plus grossier e plus dense typos de calcification esseva trovate solmente in conditiones benigne: in fibroadenoma, mastitis plasmocytic, cystes calcificante, o arteriosclerosis. Benigne massas mammari esseva homogeneemente dense, ronde o lisiemente lobulate, e circumdate de un tenue strato de grassia radiolucente. Illos retroprimeva tissu normal e esseva responsabile solmente pro alterationes local. Maligne tumores esseva responsabile solmente pro alterationes local. Maligne tumores esseva plus dense in le centro; illos habeva spiculate margines irregular, invadeva le tissu adjacente, e esseva usualmente associate con le un o le altere lesion secundari in le mamma.

Super le base de constatationes roentgenologic sol, 238 ex 245 canceres del mamma esseva registrate como maligne. In 5 del non assi registrate casos de cancere, le tumor esseva removite al tempore del biopsia ante le hospitalisation, e nulle residue carcinoma esseva trovate in le specimen del post-irradiatori mastectomia radical. In 2 casos le examinator non habeva essite informate del location probabile del tumor, e isto non esseva projicite in le roentgenogramma. Omne le lesiones benigne, con solmente 20 exceptiones, esseva registrate como tales. Si nos considera solmente le neoplasmas maligne, le error definite in le diagnose per roentgenographia esseva 2 ex 240 o 0,83 pro cento. Maligne tumores esseva trovate in 19 mammas considerate, a base clinic, como negative. Nulle mamma esseva trovate normal pro le qual le reporto radiologic describeva un lesion.

Difficultates e fontes de error es discutite detaliatemente.