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Review Articles

Screen Film Mammography, Current Status

M.A. Rahim Khan, Satwat Jehan Sheikh
Department of Radiology, Shaikh Zayed FPGMI, Lahore

INTRODUCTION

Mammography is the radiographic examination of the breast and may be undertaken on symptomatic or asymptomatic (screening) patients. It is carried out using screen-film technique. Mammography is the only available effective means for early detection of breast cancer. Early detection of breast cancer greatly increases the effectiveness of treatment and has the additional advantage of breast conservation surgery. A small tumor can be removed by lumpectomy followed by radiation and/or chemotherapy. Although some doubt exists about the benefit of screening mammography for younger women, virtually all studies show an improved survival for women over 50 years.

History

The history of mammography can be arbitrarily subdivided into three periods[1].

- The Age of Pioneers
- The Age of Technical Progress
- The Modern Era

The age of pioneers

1913: Albert Salomon, a surgeon, reported the usefulness of radiography of mastectomy specimens to reveal the spread of tumor to the axillary lymph nodes.

1930: Stafford L. Warren, reported the use of a stereoscopic technique for in vivo mammography.

1949: Raoul Leborgne reported the presence of radiologically visible micro calcifications in breast cancers. He was one of the first to recognize the importance of breast compression for improving the image quality. Leborgne emphasized the radiographic difference between benign and malignant calcifications.

1960: Robert L. Egan described a high mA-low kV mammographic technique.

1963: Gerald Dodd became the first person to perform needle localization of non palpable, mammographically visible lesions before biopsy.

1963 66: Philip Strax, Louise Veret and Sam Shapiro organized the first randomized, controlled trial of periodic screening with physical examination and mammography.

1971: Stephen Gallager and Martin published their concept of "minimal" breast cancer which they defined as a highly curable lesion. They were the first to recognize a focal "new density" in serial mammograms as a sign of early carcinoma.

The age of technical progress

1965: Charles Gros (France), developed the first "dedicated" mammography X-ray unit.

The modern era

1970: The Dupont Company produced the first marketed dedicated screen-film mammography system. The Eastman Kodak Company followed with its own high detail screen-film combination and introduced the vacuum cassette to mammography.

1974: Myron Moskowitz and his colleagues presented the early results of screening.

1977: Edward A sickles, Kunio Doi & Harry K. Genant published the results of their investigation of magnification mammography.

1976: Howard Frank, Feris Hall and Michael Steer described a needle hookwire assembly for pre-operative localization of non-palpable lesions found at mammography.

EQUIPMENT AND METHODS

Dedicated X-ray units, specially designed for mammography are widely available. They consist of:

- Molybdenum Anode
- Molybdenum filter
- Moving Grid
- Automatic Exposure Control
- Motorized or manual compression
- Selection of compression devices

For screen-film mammography, molybden

targets are used. They are efficient at producing a low energy X-ray beam (in the range of 17.4-19.6 KeV) so as to provide high contrast. Filtration material of 0.03 mm of molybdenum is added to the beam to produce minimal hardening. The X-ray tube window is made of beryllium. Moving grids specially designed for mammography are employed to reduce the scatter radiation. Compression plates of 1-4 mm plastic are used and are either motorized or manually operated. The screen film combination for mammography utilizes a single high definition screen in contact with a single emulsion film. New high speed, two-screen, double-emulsion screen film combinations have been introduced recently.

For pre biopsy needle localization of breast lesions, stereotactic devices can be used. They however, carry little advantage over the biplane method for pre biopsy localization.

One of the newer advances in mammography is computer aided diagnosis. Digital radiography has stimulated studies comparing digital mammography with screen film mammography. Examination with current low-dose technique (mean breast dose of 0.17 rad for a two view study) carries a theoretical risk of about one excess cancer case/year/2 million women examined. The hypothetical risk of one excess death/4 million women/year is therefore extremely small[2].

Mammographic positioning

Mammography has been described as the science of imaging and the art of positioning. Proper mammographic positioning significantly enhances the chances of earlier detection of a developing breast carcinoma. A quality mammogram includes images of high contrast and optimum detail in which all or as much of the breast as possible can be seen. A mammogram in which breast has been properly positioned and is inclusive of all or nearly all the breast tissue is essential for confident interpretation[3].

Compression

Compression is one of the most important aspects of mammographic positioning. A technologist who explains the procedure and importance of the compression to the patient usually achieves the best results. The advantages of optimal compression are that it:

1) reduces the amount of radiation absorbed by the breast.
2) separates overlapping structures,
3) reduces the chance of motion unsharpness due to immobilization.

Standard or routine views

Mammography positioning can be divided into standard and supplemental views.

The standard images for two view screening mammography should include Mediolateral Oblique (MLO) and craniocaudal (CC) views[4,5].

Mediolateral oblique view (MLO)

The MLO view is the more important of the two views and is preferred over the 90 degree lateral projection because more breast tissue is visualized and optimal compression is easily achieved[6]. The natural breast mobility plays a very important role in mammographic positioning. The MLO view should include pectoral muscle projecting obliquely across the posterior part of the film and extending down to the level of the nipple. The intramammary fold when included at the bottom of the film ensures adequate inclusion of lower posterior portion of the breast. Properly performed, the MLO view is a view of virtually all of the breast (Fig. 1a).

Craniocaudal view (CC)

The cc view includes all the breast tissue except the far lateral portion. An important limitation of the cc view traditionally performed is its exclusion of much of the upper posterior and extreme lateral portions of the breast[7,8,9]. Properly performed CC view is a view of virtually all but the most lateral and axillary portion of the breast (Fig. 1b).

Supplemental views

Modified views my be needed to resolve question relating to location and detailed features of a perceived lesion. These views include:-

1. The XCC view (exaggerated cc)
2. Tangential views.
3. Spot compression views.
4. Magnification views.
5. Cleavage view
6. 90 degree lateral view.
7. View of mastectomy site.
8. Axillary view.

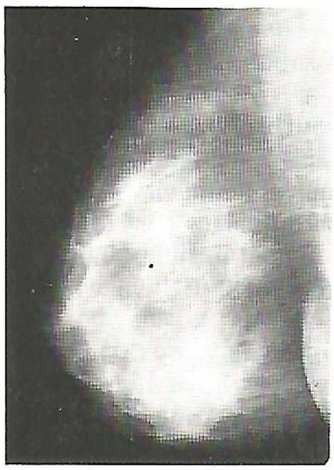

Fig. 1a

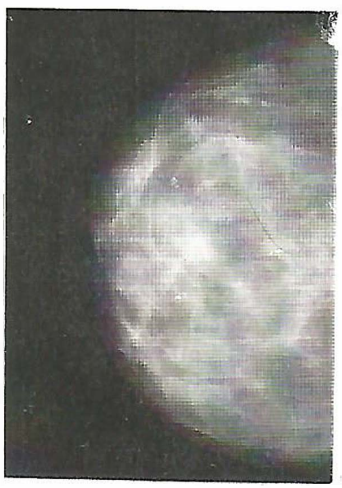

Fig. 1b

Fig. 1: Normal mammogram. (a) Mediolateral oblique view (MLO). (b) Craniocaudal view (CC).

Role of Screening Mammography in Reducing Breast Cancer Mortality

The control of any disease involves a combination of prevention, early diagnosis & treatment. In case of breast cancer, the cause is unknown, so prevention is not possible. In spite of advances in treatment, there has been little or no change in the mortality from breast cancer[10]. However, it is an established fact that the more extensive a tumor of a given type at the date of treatment the worse the prognosis. Thus the only rewarding approach to reduce mortality is to detect and treat the disease at an earlier stage when the balance between the tumor and the host is more favorable. Mammography is the only method to date which has demonstrated the ability to detect breast cancer at an earlier stage with high sensitivity and specificity[11].

Breast cancer survival depends upon the lesion size and lymph node status. Smaller lesions with no histological evidence of axillary mets, have the best prognosis[12,13]. Screening mammogram can detect such early cancer long before they are clinically palpable. Although there has been general agreement that such screening should be performed in women between 50 and older, some investigators have questioned the advisability of screening women between 40 and 50 years of age[14]. The reluctance to screen younger women may be partially attributed to concern about radiation risk, however such risk is negligible or non-existent at the low doses of current mammographic technique[15].

Type of evidence

In the screening for cancer the principal question is whether early detection and increased survival necessarily results in mortality reduction. In order to answer this question it will be necessary to evaluate whether or not certain biases affect the outcome of screening.

Lead time bias

This is defined as the length of time between detection at screening and the time at which the disease would otherwise be detected had there been no screening[16]. The time from diagnosis to death would be longer than had the cancer been detected clinically, yet the date of death would have been unchanged. Thus the extra time the cancer was observed (the lead time) increased the survival time, but did not change the outcome.

Length time bias

This arises because of variability in the rate of progression of the disease for a given site of cancer, so that for example some cancers are aggressive and will lead to death just a few years after initiation. whereas other cancers of the same site are indolent and may take decades. Since the latter spend more time in the pre clinical stages there are more opportunities for the incidental diagnosis. It follows that in a group of cancer diagnosed early there will be a disproportionate number of indolent cases with good survival.

Table 1: Breast cancer mortality results according to study of mammographic screening together with statistical features of each study

Study	No. studied (1000s)		Comp	Contami-	Follow-up	Relative Risk@
	Screening	Control	liance* (%)	nation# (%)	(years)	(95% CI)
Randomized Control Trial						
HIP (Shapiro et al. 1988)	30	31	65	NK	18	0.79 (0.62-0.99)
Two counties (Tabar et al. 1989)	77	56	91	13	08	0.70 (0.55-0.87)
Malmo (Anderson et al. 1988)	21	21	74	24	11	0.83 (0.60-1.14)++
Edinburgh (Roberts et al. 1990)	23	22	61	NK	07	0.84 (0.58-1.18)
Geographical Control Study						
TEDBC (1988)	23	127	72	NK	07	0.78 (0.58-1.04)
Study of screening attenders						
BCDDP (Morrison et al. 1988)	55	SEER			9	0.80 (0.72-0.87)
Nijmegen (Verbeck et al. 1984)	20	Nonattenders			7	0.48 (0.23-1.00)
Utrecht (Collete et al. 1984)	15	Or			09	0.30 (0.13-0.70)
Florence (Palli et al. 1986)	15	Uninvited			8	0.53 (0.29-0.95)

* Proportion of screening group attending at first screening round.
# Proportion of controls screened atleast once during the study period.
@ Risk of dying of breast cancer in screening group relative to risk in controls.
+ + Derived from figure in publication: at the planned end of the trial it was only 0.96 (0.68-1.35).
HIP Health Insurance Plan of New York Study.
TEDBC Trial of early detection of breast cancer.
BCDDP Breast Cancer Detection Demonstration Project.
SEER Surveillance, Epidemiology and End Results.
NK Not Known.
CI Confidence Interval.

(Reproduced from clinical radiology 43: 78(1991), Cuckle H. breast cancer screening by mammography, an overview)

These biases mean that to evaluate screening for cancer the mortality rate and not the survival rate has to be used, comparing it in those who are screened and similar individuals who are not. This can be best achieved in a randomized controlled trial, in which the end point is mortality from breast cancer, not survival[17]. There are now nine published studies and the following table summarizes their statistical features together with the relative risk of dying from breast cancer attributable to screening using the most recent follow up information. The results are all consistent with screening having protective effect as large as 40%. It is remarkable that all the studies support the same general conclusion that mammographic screening for breast cancer is capable of reducing mortality from the disease (Table 1).

Screening guidelines

The current recommendations of both the American College of Radiology[18] and the American Cancer Society[19,20] for screening mammography are as follows:-

1. Women should have a base line mammogram between the ages of 35 and 39 years.
2. Starting at age 40, women should have mammogram once a year or every other year, depending upon physical examination and risk factors.
3. After the age of 50 years, a yearly mammogram should be done.

Premenopausal women whose mothers or sister have breast cancer, particularly bilaterally should probably begin screening 10 years earlier than usually suggested[21].

General principles of mammographic interpretation

The breast varies in appearance over the years changing from normally dense breast in young women to fatty glandular type specially following pregnancies. In the menopausal and post menopausal age groups the glandular tissue is replaced by fat eventually giving a fatty atrophic breast. The breast has different appearances during

pregnancy and post partum period and becomes more dense and vascular. The breast is like a finger print, each one is unique. The best we can do on initial mammogram is to decide whether the appearance falls outside of our acceptable normal range of appearance.

The aim of mammography is to detect a solitary geographic area with different appearance from all other areas in the ipsilateral or contralateral breast, rather than to differentiate between benign and malignant.

Principal of multiplicity and bilaterality

When there are multiple and bilateral abnormalities of similar appearance and having a high probability of being benign, the choice of follow up rather than biopsy is the appropriate approach. In case of multiple unilateral abnormalities, one should consider the possibility of biopsy of one or two of the masses. The solitary lesion that has high probability of being benign should be biopsied or placed in follow up protocol.

Role of ultrasound

The primary role of ultrasound is to differentiate a simple cyst from a solid mass in the breast. It is not reliable in differentiating solid benign and malignant lesions. Ultrasonography should only be used in conjunction with mammography and physical examination.

Follow up protocol

Often a decision is made not to biopsy a solitary non-palpable abnormality, with mammographic appearance that has a high probability of being benign. The patient is then placed into the follow up protocol to be certain that the abnormality remains stable in appearance. This protocol can also be used in situation in which there are multiple bilateral abnormalities that have high probability of being benign. The aim of follow up mammogram is to assure stability of the findings that have high probability of being benign. The protocol used for follow up is based upon a survey reported by Homer MJ[22]. There are three parts to a follow up protocol. (a) The time of the initial follow up examination, (b) interval between follow up examination and (c) the total length of time required to conclude that the abnormality is stable and there is no need for further follow up. The initial follow up examination to be performed within six months and if the lesion is stable two additional examination at yearly intervals. This provides a total follow up of 2 1/2 - 3 years from the time of initial mammogram.

MAMMOGRAPHIC ANALYSIS OF BREAST MASSES

Stellate carcinoma

A stellate or spiculated mass is a common mammographic appearance of carcinoma, the irregular spiculated margins are suggestive of invasion of the surrounding tissue (Fig. 2). Scirrhous Carcinoma is the descriptive term for invasive ductal carcinoma that shows stellate configuration. Approximately 90% of the invasive breast cancers arise from the ducts and are classified as invasive ductal carcinoma[23]. A small minority of these may contain well differentiated ductal structures to be further classified as tubular Carcinoma[24].

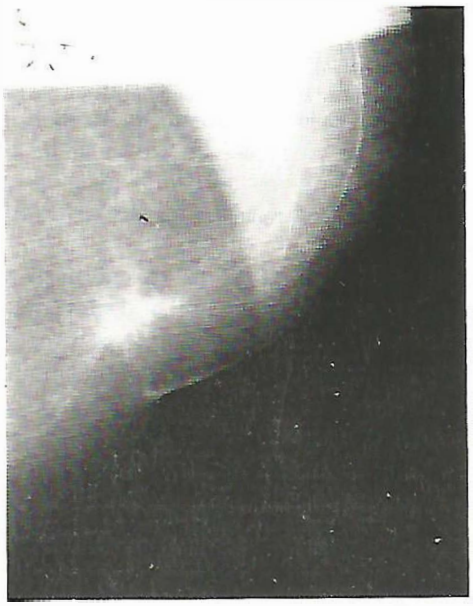

Fig. 2: Stellate mass with spiculations and focal skin retraction ------ carcinoma.

As of 10% of invasive breast cancers arise from the lobules (terminal acini) and are referred to as lobular carcinomas[25] Invasive lobular carcinoma presents as asymmetric density/architectural distortion and less frequently as spiculated mass than does invasive ductal Carcinoma. Uncommonly invasive lobular carcinoma may present as a round mass with partially ill defined margins[25].

Circumscribed carcinoma

Circumscribed carcinoma appears as a circumscribed mass on mammogram, spiculation is absent.

Although most have borders, which are at least partially poorly defined, some have completely well defined borders. Circumscribed carcinomas include medullary[26], papillary and mucinous carcinomas as well as some invasive ductal carcinoma[27] (Fig. 3).

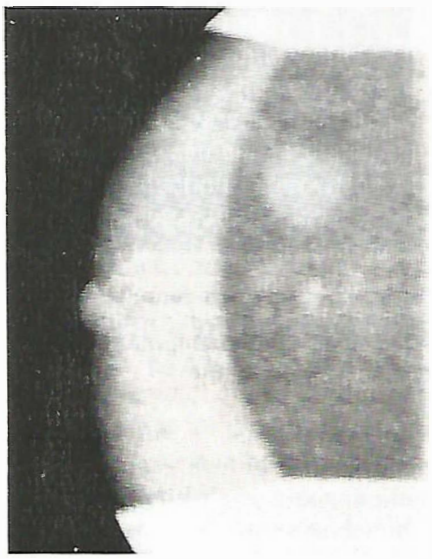

Fig. 3: Well circumscribed mass with partially ill defined margins ------ FNA Biopsy showed Carcinoma.

Medullary carcinomas exhibit varying degree of lobulation.

Sarcoma

Less than 1% of primary breast cancers are lymphosarcomas or fibrosarcomas. They appear well defined and show minimal irregularity of the margins.

Lymphoma

Primary Lymphoma of the breast is rare. Secondary involvement manifests as a well defined mass with or without marginal irregularity or diffuse increased density with skin thickening.

Metastases

Breast Metastases present as discrete nodule which are usually solitary (85%) and less often multiple (15%). The majority will be found in upper outer quadrant[28, 29].

Calcification

Malignant Calcification occur with or without the presence of a tumor mass. Calcification associated with breast cancer are dystrophic; they are deposited because the tissue is abnormal. The calcifications of malignancy are typically grouped or in clusters, pleomorphic (Varying in size (shape), fine, linear and branching and numerous[30]. The greater the number of calcification in a cluster the greater the likelihood of malignancy. A cluster containing less then five discrete calcification is unlikely to represent malignancy.

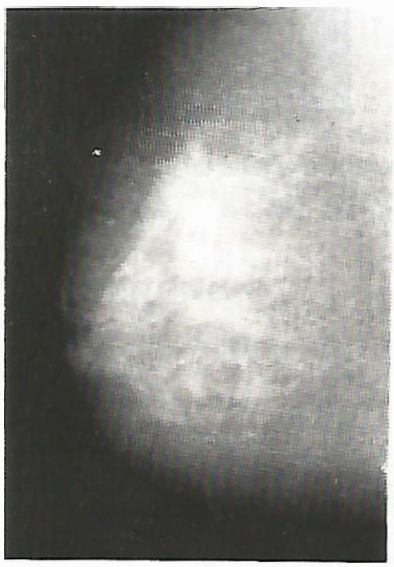

Fig. 4: Irregular high attenuation mass showing extensive pleomorphic microcalcifications malignancy.

Benign Calcifications are larger than malignant calcifications. They are round and monomorphic (uniform in size and shape) and scattered. Coarse, egg shell and gravity dependent calcification are benign.

Benign Breast lesions

Fibroadenoma

This is the most common benign tumor of the breast. They appear mammographically as well defined, rounded, oval masses with smooth or lobulated margins. They are frequently multiple and bilateral and generally arise in younger women. Calcification may be seen which is coarse or primarily distributed at the periphery of the mass (Fig. 5).

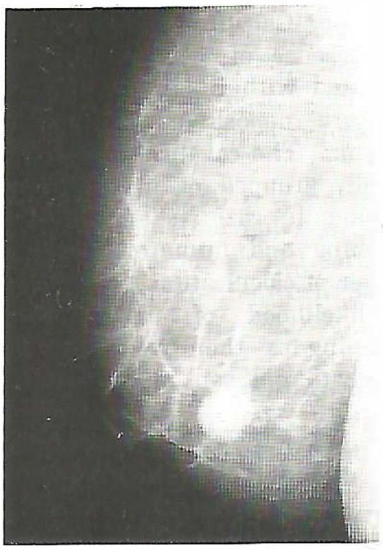

Fig. 5: Well defined mass with lobulated margins and eccentric coarse calcifications, solid on Ultrasound --------- Fibroadenoma.

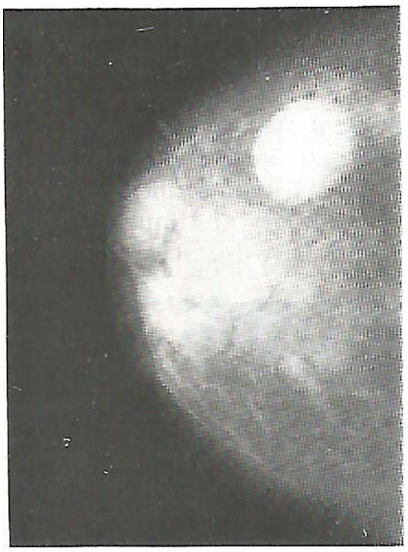

Fig. 6: Multiple well defined rounded and oval masses of homogeneous density with surrounding thin lucent "halo". Ultrasonography showed multiple cysts.

Cysts

Breast cysts appear as round or oval well circumscribed masses. The margins may be well defined or partially obscured by the surrounding fibroglandular tissue. They can not be differentiated from fibroadenomas mammographically. They are often multiple and bilateral. Calcification is infrequent but peripheral curvilinear. Calcification may be seen. Cysts are more common in women aged 40-60 while fibroadenomas are more common in women younger than 35.

The strict sonographic criteria of a simple cyst are round or oval echo free area with well defined margins particularly posterior, and increased through transmission (Fig. 6).

Intramammary lymph nodes

Typically intramammary L.N. are less then 1.5 cms in size. and are frequently seen in the outer portion of the breast. Characteristically they have notched margins or central leucency due to fat replaced hilum.

Hamartoma (Lipofibroadenoma)

Well defined mass with internal fat density and surrounded by a fibrotic pseudo capsule.

Lipoma

A lipoma appears as a well defined fatty density surrounded by a thin capsule.

Papilloma

Intraductal papilloma usually occurs in the retroareolar region and may cause serous or serosanguineous nipple discharge. Usually they are small and are not discernible mammographically.

Galactocele

The galactocele is a milk containing cyst that develops during lactation. Some have a clearly demarcated fat/fluid level or fluid / calcium level.

Cystosarcoma phylloides

The tumor is well defined, round/oval with smooth or lobulated margins[31,32].

Sclerosing adenosis

Sclerosing Adenosis is characterized by acinar proliferation and substantial fibrosis among the glandular elements. This condition may present as a stellate mass, irregular density or a circumscribed mass[33].

Fat necrosis

The causes of fat necrosis include surgical procedures and blunt trauma. The mammographic appearance vary from a stellate mass indistinguishable from carcinoma to typically benign appearance of a rounded lesion containing fatty density and surrounded by a fibrous capsule. The capsule may calcify in egg shell fashion. The central lipid material may also calcify showing dense macro-calcification.

Radial Scar

It is a pathological condition in which ductal element surrounded by fibrous tissue radiate from a central sclerotic focus. Radial scar shows as an irregular non calcified mass often associated with architectural distortion, indistinguishable from carcinoma.

EVALUATION OF A PALPABLE MASS

Image protocol for a patient presenting with clinically palpable mass should vary with age and family history as shown in the following table. The reasons are 1. Incidence of breast cancer in women younger than 35 years is less than 3% and less than 1% in women younger than 30 years. The other consideration is the theoretic radiation risk from mammography. Although the risk is quite small the women younger than 35 years are known to be more sensitive to radiation.

Patient age (Years) Imaging protocol

Younger than 20	Sonography only
20 - 30	Sonography first Mammography (Single view unilateral) If sonography does not show a simple cyst.
30 - 35	If no family history of breast cancer, The protocol is same as for 20-30 years. If mother or sister with breast cancer then follow protocol for the age 35 and above.
35 and older	Bilateral two view mammography first. Sonography, if mammography negative or nonspecific.

(Reproduced from breast masses Stephen A. Feig Radiologic Clinics of North America 1992; 30: 89).

False negative mammogram

Every radiologist interpreting mammogram will experience a situation when mammogram shows no abnormality despite the fact that clinician and the patient are able to palpate a definite mass. The false negative rate of mammograms is approximately 5-15%[34].

Reasons for false negative mammograms are:

1. Failure to image the area of interest.
2. Obscuration of the mass by the overlapping fibroglandular breast tissue.
3. Poor image quality.
4. Errors of perception.
5. Breast cancer indistinguishable from normal breast tissue.

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The Authors:

M.A. Rahim Khan,
Medical Officer,
Department of Radiology,
Shaikh Zayed FPGMI,
Lahore.

Satwat Jehan Sheikh
Medical Officer,
Department of Radiology,
Shaikh Zayed FPGMI,
Lahore.

Address for Correspondence:

M.A. Rahim Khan,
Medical Officer,
Department of Radiology,
Shaikh Zayed FPGMI,
Lahore.