ROLE OF CONTRAST ENHANCED SPECTRAL MAMMOGRAPHY AFTER CONSERVING BREAST SURGERY

Omnia Mokhtar Nada; Sahar Mohamed El Fiky; Nivine Abdelmonem Chalabi; and Merhan Ahmed Nasr*

Radiodiagnosis Department - Faculty of Medicine - Ain Shams University
And * Radiodiagnosis Department; National Cancer institute
Corresponding author:
Omnia Tarek Ahmed
Mobile: (+2) 01006260675

E.mail:
omniahz42@gmail.com

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ABSTRACT:

Background: *CESM is an imaging technique combining digital mammography with intravenous injection of iodinated contrast media to detect hyper vascularized lesions. Adding the iodinated contrast agent to Mammography facilitates the visualization of breast lesions. Contrast enhanced spectral mammography (CESM) is feasible and has an important role in evaluation of recurrent breast mass lesion after surgical treatment of primary breast cancer.*

Aim of the Work: *To illustrate the growing and useful role of CESM in breast lesions detected post conserving breast surgery.*

Patients and Methods: *This study was carried on 54 female patients presenting with history of previous breast conserving surgery on either breast sides, which requires follow up. The results were studied and compared to the pathological results.*

Results: *Dual-energy CESM has an important role in detection of recurrent breast cancer mass lesion and its ability to differentiate between positive lesions and benign post-operative findings.*

Conclusion: *CESM, then seems to be a promising tool for increasing the sensitivity of mammography, CESM as an adjunct to mammography is expected to improve diagnostic accuracy compared to mammography alone. CESM reduced false positive results. CESM helped in assessment of recurrent breast disease.*

Keywords: *Breast cancer; Conserving Breast Surgery; Contrast Enhanced Spectral Mammography;*

INTRODUCTION:

Breast cancer is the most common non-skin cancer and the second leading cause of cancer related death in women. Breast cancer strikes women of all ages, races, ethnicities, socioeconomic strata, and geographic locales[(1)].

Contrast-enhanced spectral mammography (CESM) is a new breast imaging technique that aims at demonstrating breast carcinoma angiogenesis. It detects abnormal contrast enhancement by dynamic iodinated contrast medium study via intravenous injection using digital mammographic unit on the basis of subtraction of low and high energies[(2)].

The advantages of CESM over contrast enhanced-MRI are being of lower cost of equipment and contrast medium, shorter time of study and its validity in cases with claustrophobia to MRI. There are no limitations for overweight patients, or patients with a cardiac pace-maker, a vascular stent, a metallic prosthesis, or old magnetic devices and clips[(3)].

Breast-conserving therapy (BCT) has become firmly established as a standard therapeutic approach for eligible women with

early stage breast cancer over the past 2 decades, replacing mastectomy as the predominant treatment. BCT is defined as excision of the primary breast tumor with a rim of adjacent normal breast tissue sufficient to achieve negative resection margins, with or without axillary sentinel lymph node (SLN) biopsy or dissection, usually followed by irradiation[(4)].

Mammography is performed after breast conservation therapy to confirm removal of the lesion, to identify post-procedural fluid collections, to detect residual and recurrent cancer, and to screen for metachronous cancers in the ipsilateral breast and the contralateral breast[(4)].

The treated breast is a rapidly changing organ, and early postoperative imaging may demonstrate many findings, which usually evolve and resolve over time. Masses, fluid collections, architectural distortion, scarring, edema, skin thickening, and calcifications are post-treatment findings that may mimic or mask local tumor recurrence. Radiation therapy not only exacerbates these changes but also delays resolution[(5)].

Dual-energy contrast-enhanced Spectral mammography is a useful technique in identification of lesions in mammographically dense edematous breasts and capable of demonstrating lesions that are not visible by standard mammography. It serves as a promising means of follow-up of cases presenting by edema after conservative breast surgery and chemotherapy[(6)].

CESM can be used in the assessment of residual and recurrent disease, substantially aiding in differentiation of recurrent enhancing tumoral tissue, from non-enhancing scar tissue in post-operative edematous breasts, with higher specificity compared to Mammography combined with US[(7)].

It may be a useful guide for biopsy and its accuracy may be increased when combined with tomosynthesis [(8)].

AIM OF THE STUDY:

The present study aims to illustrate the growing and useful role of CESM in breast lesions detected post conserving breast surgery.

PATIENTS AND METHODS:

The study was conducted on 54 Female patients after conserving breast surgery for histo-pathologically proven breast cancers presented at radiology department at National Cancer Institute.

Patients included in the study are breast cancer patients post conserving surgery either asymptomatic patients for follow up or symptomatic patients e.g. mass, pain, discharge with no age group predilection. While patients excluded from the study are those with contraindication to IV contrast material: those known to have history of allergy from contrast media such as anaphylactic reaction, renal failure, poor general condition or patients who are pregnant.

The contrast enhanced mammography studies were performed using 2000D full-field digital mammography system from GE Healthcare.

Procedure (Dual-energy subtraction contrast enhanced Spectral mammography examination):

A) Standard precautions need to be taken prior to examination:

   - Patient fasts for about 4-6 hours.
   - Patients were properly assessed for renal sufficiency and determine if there is any history of reactions to contrast agents.

B) After reading the informed consent and clarification of all the steps, value of examination and possible hazards or side effects, the consent form was signed by the patient or her guardian.

C) Examination: A catheter was inserted into the contra-lateral antecubital vein. The nonionic iodinated contrast agent (Omnipaque 350, Guerbet France) was administered manually at a dose of 1.5 ml /kg body weight and at a rate of ~3 ml/ second. A pair of low- and high-energy images were acquired after contrast injection using a modified full-field digital mammography system, then the two images were combined to enhance areas of contrast uptake. After a delay of about 2 minutes, the breast is compressed and the low- and high-energy exposures are given during a single breast compression. Exposures will be taken in MLO and in CC after the injection. Selected X-ray beam voltages (low-energy beam, 22-33 kVp; high energy beam, 44-49 kVp).

Interpretation:

Detected enhancing lesions were assessed & compared to histopathological & cytological analysis (obtained from suspicious lesions) and/or the follow up examination of therapy induced enhancing lesions such as fibrosis, necrosis & inflammation.

Methods of analysis:

All conventional mammographic examinations were analyzed by experienced radiologists and all CESM examinations were analyzed separately by a consensus of at least two experienced radiologists.

RESULTS

Fifty four abnormal findings were detected in 54 patients. Findings included 27 architectural distortions, 5 calcification, 2 breast edema (as the only presentation) and 20 asymmetries.

Table (1): Distribution of cases obtained in our study showing the primary pathology and hormonal receptors.

		Count	%
Primary pathology	Not available	2	3.7%
	IDC	39	72.2%
	IDC GII With neoroendocrine & mucinous differentiation	2	3.7%
	IDC GIII medullary feature with no intraductal component	3	5.6%
	ILC GII	3	5.6%
	Mixed ID & IL carcinoma GII	3	5.6%
	Paget disease of the nipple	1	1.9%
	Metaplastic carcinoma GIII	1	1.9%
Hormonal ER	-ve	17	35.4%
	+ve	31	64.6%
Hormonal PR	-ve	18	37.5%
	+ve	30	62.5%
Hormonal HER2	-ve	31	64.6%
	+ve	13	27.1%
	equivocal	4	8.3%

Table (2): Distribution of cases as regarding the suspicious architectural distortion, calcifications & focal asymmetries in mammography, CESM & final pathological diagnosis.

		Count	%
mammo/architectural distortion	-ve	28	51.9%
	+ve	26	48.1%
CEM/architexture distortion	-ve	46	85.2%
	+ve	8	14.8%
biobsy architexture distortion	-ve	49	90.7%
	+ve	5	9.3%
mamo/calcifications	-ve	47	87.0%
	+ve	7	13.0%
CEM/calcifications	-ve	51	94.4%
	+ve	3	5.6%
biopsy calcifications	-ve	50	92.6%
	+ve	4	7.4%
mamo/ density	-ve	33	61.1%
	+ve	21	38.9%
CEM/density	-ve	41	75.9%
	+ve	13	24.1%
biobsy density	-ve	46	85.2%
	+ve	8	14.8%

CESM examination after conventional mammography showed: Enhancement observed in 22 of 54 lesions of which 16 were malignant and 6 were benign. The pathologically proven malignant tumours showed heterogenous enhancement in 7 cases, homogenous enhancement in 6 cases & non mass enhancement in 3 cases. No Enhancement observed in 32 of 54 lesions of which 1 was proven to be malignant lesion. In that case, the area of the architectural distortion & microcalcification showed no pathological enhancement by CESM (false negative). Enhancement was observed in 6 of the benign breast lesions; 1 ring enhancements, 3 faint homogenously enhancing nodules & 2 revealed diffuse increased parenchymal enhancement.

Table (3): CESM Pattern of enhancement and their percentages

CESM enhancement pattern	No. of cases		Percentage
Heterogeneous	7		13%
Homogeneous	9	6 malignant	11%
		3 benign	5%
Non-mass enhancement	3		6%
Ring enhancement	1		2%
Increased parenchymal enhancement	2		4%
No abnormal enhancement	32		59%

16/54 (30%) showed post contrast enhancement & were diagnosed as malignant by contrast enhanced mammography and confirmed to be malignant by pathology (true positive). 6/54 (11%) showed post contrast

enhancement & were diagnosed as benign by contrast enhanced mammography and confirmed to be benign by pathology (true negative). On the other hand, non-contrast uptake was observed in 32/54 (59%) cases, and 1/32 (3%) was malignant proved by pathology (false negative).

All suspicious breast lesions were diagnosed pathologically by means of surgery, excisional biopsy, stereotactic biopsy, true cut biopsy. Detailed description for the number and percentage of the enhancing breast lesions are illustrated in table (4)

Table (4): Total number of benign and malignant enhancing breast lesions.

Final pathologic diagnosis of enhancing lesions	No. of cases	Percentage
Benign	6	27.27%
Malignant	16	72.73%
Total	22	100 %

Detailed description for the number and percentage for each pathological diagnosis of biopsied lesions are illustrated in table (5).

Table (5): Total number of cases with final pathological diagnosis of biopsied lesions.

Final pathologic diagnosis	No. of cases	Percentage
Invasive duct carcinoma grade II	11	50 %
Invasive duct & Lobular carcinoma	1	4.55%
Invasive lobular carcinoma	2	9.09%
Ductal carcinoma in situ (DCI)	1	4.55%
Undifferentiated carcinoma	1	4.55%
Benign lesions	6	27.27%
Total	22	100%

Table (6): Accuracy of mammography in detection suspicious architectural distortion

		Biopsy architexture distortion				
		+ve		-ve		P value
		Count	%	Count	%	
mammo/architectural distortion	+ve	5	100.0%	21	42.9%	0.021
	-ve	0	0.0%	28	57.1%	

Table (7): Sensitivity, specificity, PPV, NPP & accuracy of lesions detected as suspicious architectural distortion in mammography compared to pathology.

Statistic	Value	95% CI
Sensitivity	100.00%	47.82% to 100.00%
Specificity	57.14%	42.21% to 71.18%
Positive Predictive Value	19.23%	14.70% to 24.75%
Negative Predictive Value	100.00%	
Accuracy	61.11%	46.88% to 74.08%

Table (8): Accuracy of CESM in detection of suspicious architectural distortion

		biopsy architectural distortion				
		+ve		-ve		P value
		Count	%	Count	%	
CEM/architectural distortion	+ve	5	100.0%	3	6.1%	< 0.001
	-ve	0	0.0%	46	93.9%	

Table (9): Sensitivity, specificity, PPV, NPP & accuracy of lesions detected as suspicious architectural distortion in CESM compared to pathology.

Statistic	Value	95% CI
Sensitivity	100.00%	47.82% to 100.00%
Specificity	93.88%	83.13% to 98.72%
Positive Predictive Value	62.50%	35.76% to 83.30%
Negative Predictive Value	100.00%	
Accuracy	94.44%	84.61% to 98.84%

Table (10): Accuracy of mammography in detection of suspicious calcification

		Biopsy calcifications				
		+ve		-ve		P value
		Count	%	Count	%	
mamo/calcifications	+ve	4	100.0%	3	6.0%	< 0.001
	-ve	0	0.0%	47	94.0%	

Table (11): Sensitivity, specificity, PPV, NPP & accuracy of lesions detected as suspicious calcifications in mammography compared to pathology.

Statistic	Value	95% CI
Sensitivity	100.00%	39.76% to 100.00%
Specificity	94.00%	83.45% to 98.75%
Positive Predictive Value	57.14%	30.80% to 79.98%
Negative Predictive Value	100.00%	
Accuracy	94.44%	84.61% to 98.84%

Table (12): Accuracy of CESM in detection of suspicious calcification

		Biopsy calcifications				
		+ve		-ve		P value
		Count	%	Count	%	
CEM/calcifications	+ve	3	75.0%	0	0.0%	< 0.001
	-ve	1	25.0%	50	100.0%	

Table (13): Sensitivity, specificity, PPV, NPP & accuracy of lesions detected as suspicious calcifications in CESM compared to pathology.

Statistic	Value	95% CI
Sensitivity	75.00%	19.41% to 99.37%
Specificity	100.00%	92.89% to 100.00%
Positive Predictive Value	100.00%	
Negative Predictive Value	98.04%	90.16% to 99.64%
Accuracy	98.15%	90.11% to 99.95%

Table (14): Accuracy of mammography in detection of suspicious focal asymmetries.

		Biopsy density				
		+ve		-ve		P value
		Count	%	Count	%	
mamo/ density	+ve	8	100.0%	13	28.3%	< 0.001
	-ve	0	0.0%	33	71.7%	

Table (15): Sensitivity, specificity, PPV, NPP & accuracy of lesions detected as suspicious focal asymmetries in mammography compared to pathology.

Statistic	Value	95% CI
Sensitivity	100.00%	63.06% to 100.00%
Specificity	71.74%	56.54% to 84.01%
Positive Predictive Value	38.10%	27.97% to 49.37%
Negative Predictive Value	100.00%	
Accuracy	75.93%	62.36% to 86.51%

Table (16): Accuracy of CESM in detection of suspicious focal asymmetries.

		Biobsy density				
		+ve		**-ve**		**P value**
		Count	**%**	**Count**	**%**	
CEM/density	**+ve**	8	100.0%	5	10.9%	< 0.001
	-ve	0	0.0%	41	89.1%	

Table (17): Sensitivity, specificity, PPV, NPP & accuracy of lesions detected as suspicious focal asymmetries in CESM compared to pathology.

Statistic	Value	95% CI
Sensitivity	100.00%	63.06% to 100.00%
Specificity	89.13%	76.43% to 96.38%
Positive Predictive Value	61.54%	41.16% to 78.54%
Negative Predictive Value	100.00%	
Accuracy	90.74%	79.70% to 96.92%

15 cases have a variable degree of breast edema evidenced by diffuse increased parenchymal density, coarse trabecular pattern, and increased skin thickness.

Table (18): Distribution of cases received radiation therapy prior to examination and cases with associated breast edema

		Count	%
Radiation	no	23	42.6%
	yes	31	57.4%
Edema	-ve	39	72.2%
	+ve	15	27.8%

Table (19): Average age (in years) of the female patients included in our study

	Mean	Standard Deviation	Median	Minimum	Maximum
Age(years)	47.46	10.09	47.50	28.00	69.00

Table (20): Average duration (in months) between the surgical & radiational intervention and the CESM examination.

	Mean	Standard Deviation	Median	Minimum	Maximum
Surgery to CESM (months)	33.56	40.66	18.50	1.00	216.00
Radiation to CESM (months)	27.87	34.32	12.00	1.00	120.00

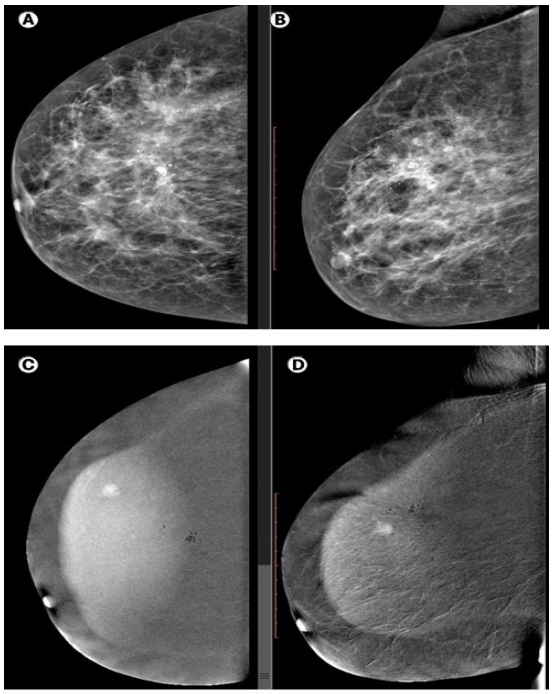

Figure (1): A female patient 56 years old, underwent right CBS 12 years ago for IDC GII (T2N0M0), hormonal profile (+ ve PR, +ve ER, equivocal score 2HER2) By digital mammography: (a) Craniocaudal and (b) Mediolateral views of the right breast showed UOQ area of architectural distortion with adjacent round and dystrophic calcifications. By contrast enhanced spectral mammography: (c) Craniocaudal and (d) Mediolateral views of the right breast showed newly developed small faintly enhancing nodule. Pathological diagnosis: Recurrent Invasive Ductal carcinoma.

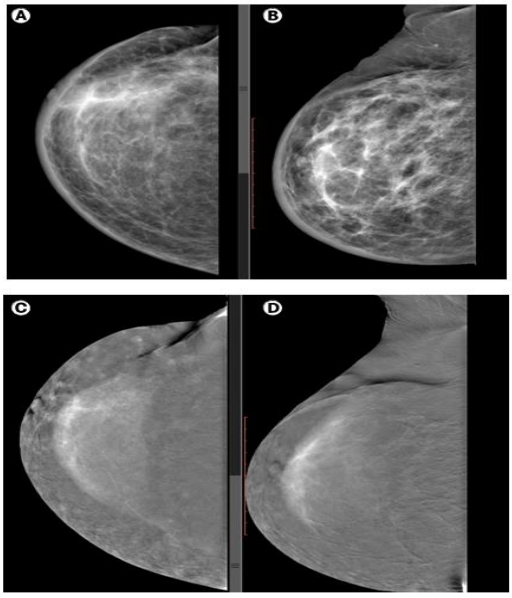

Figure (2): A 55 years old female patient with history of right breast cancer, underwent right CBS 3 years ago for IDC GII, hormonal profile (+ ve PR, +ve ER, +ve3 HER2), received chemotherapy and radiotherapy (history of left breast IDC & MRM done 2011). By digital mammography: (a) Craniocaudal and (b) Mediolateral oblique views of the right breast showed: Segmental clustered fine pleomorphic micro-calcifications, and mild Edema pattern (in the form of diffuse circumferential skin thickening with coarse trabeculations and diffuse nodular pattern of the breast). By contrast enhanced spectral mammography: (c) Craniocaudal and (d) Mediolateral oblique views of the right breast showed faint heterogenous enhancement surrounded by nodular mottled enhancement. Pathological diagnosis (stereotactic biopsy): Recurrent IDC with micro-papillary pattern.

DISCUSSION:

Women with a history of breast cancer are at risk for developing local recurrences, a second ipsilateral breast cancer, or contralateral breast cancer. Breast conservative surgery of clinical stage I and stage II breast cancer with lumpectomy and whole-breast radiation therapy has become a standard of care, with long-term studies showing no significant difference in survival rates between those treated with conserving breast surgery and those treated with mastectomy[(9)].

Loco-regional recurrences occur in approximately 5% of patients at 5 years with a local failure rate of approximately 1%–2.5% per year. In the immediate postoperative period, suspicious findings likely represent residual disease, whereas local recurrence typically occurs 3–7 years after breast conservative surgery. Early detection of local recurrence of breast cancer has been shown to significantly improve long-term survival[(5)].

To determine adequate subsequent treatment, such as re-excision or mastectomy, the accurate evaluation of residual disease and the assessment of its extent are necessary for surgical planning[(10)].

Architectural distortion and increased density at the lumpectomy site as well as post-treatment edema may impair accurate detection of recurrence by MG and US [(5)].

CESM is a new breast imaging modality. It is an imaging technique combining digital MG with intravenous injection of iodinated contrast media to detect neovascularized lesions[(11)].

We will discuss the application of CESM in the follow up of patients who had undergone breast surgery in reference to the literature.

One of the potential uses of CESM include additional evaluation of mammographic or clinical abnormalities as well as evaluation of the post lumpectomy breast for recurrent tumor[(12)].

CESM may allow decreasing the tumor recurrence rate and the number of patients with positive margins at tumor excision[(13)].

CESM has been shown to improve the probability of malignancy detection when compared with conventional mammography alone. CESM is a useful adjusts to diagnostic mammogram and promising problem solving[(3)].

This study was carried on 54 female patients showing 54 lesions presenting with history of previous conserving breast surgery on either breast sides. All patients had mammography and were referred for further study by CESM according to suspicious or indeterminate findings.

In our study, Cases were classified into 3 groups according to MG suspicious findings, either architecture distortion, calcifications or focal asymmetries.

In our study, operative bed Enhancement was observed in 22 of 54 lesions of which 16 were of malignant lesions and 6 of which were of benign lesions. No operative bed Enhancement was observed in 32 of 54 lesions of which one was proven to be malignant lesion.

Collectively the “benign enhancing lesions” group included 6/54 while the “malignant enhancing lesions” group included 16/54.

Upon correlating the CESM findings to the final diagnoses by biopsy 16 out of 22 enhancing lesions were true positives, 6 out of 22 enhancing lesions were false positives, 31 lesions were true negative, and 1 lesion was false negative.

A suspicious lesion was mainly based on the identification of contrast enhancing lesion showing irregular or speculated

margins and heterogeneous or rim pattern of contrast uptake.

In architectural distortions, mammography had a sensitivity of 100.00%, a specificity of 57.14%, a positive predictive value of 19.23%, a negative predictive value of 100.00%, and 61.11% accuracy.

In calcifications, mammography had a sensitivity of 100.00%, a specificity of 94.00%, a positive predictive value of 57.14%, a negative predictive value of 100.00%, and 94.44% accuracy.

In focal asymmetries, mammography had a sensitivity of 100.00%, a specificity of 71.74%, a positive predictive value of 38.10%, a negative predictive value of 100.00%, and 75.93% accuracy.

The high number of false positive cases in MG was due to the architectural distortion and increased breast density at the lumpectomy site as well as post-treatment edema.

In architectural distortion, CESM had a sensitivity of 100.00%, a specificity of 93.88%, a positive predictive value of 62.50%, a negative predictive value of 100.00%, and 94.44% accuracy.

In calcifications, CESM had a sensitivity of 75.00%, a specificity of 100.00%, a positive predictive value of 100.00%, a negative predictive value of 98.04%, and 98.15% accuracy.

In focal asymmetries CESM had a sensitivity of 100.00%, a specificity of 89.13%, a positive predictive value of 61.54%, a negative predictive value of 100.00%, and 90.74% accuracy.

One false negative case with calcifications was misdiagnosed due to non-apparent contrast uptake by the malignant lesion either due to its low-grade nature or due to extensive post-operative scar fibrosis around that lesion.

The false positive cases were misdiagnosed at CESM due to benign proved nature, increased vascularity in some non-malignant post-operative sequelae or non-pathologically increased background parenchymal enhancement.

Obdeijn et al.[14], *Lee et al.*[15], and *Suh et al.,* [16] found that the sensitivity of MG is only 10% (0.0–14.3%) to detect regional or loco-regional recurrences. *While et al.,* [17] found that CESM had a sensitivity of 91.17% in detecting recurrence in the postoperative breast, a specificity 75.00%, a positive predictive value of 77.5%, a negative predictive value of 90.00%, and accuracy of 82.85%

Kim et al., [18] found the sensitivity of MG in women with dense breasts is lower than that of women with scattered fibroglandular tissue (73% vs. 80%).

The low diagnostic indices in ***our study*** go in accordance with *Yalcinkaya et al.,* [19] who concluded from their study that it is difficult to assess the breast with mammography in patients who have had breast conserving surgery and radiotherapy because of parenchymal distortion and edema. For mammography the false-negative diagnosis rate which is up to 15 % in the general population is even higher for this group.

Fallenberg et al, [8] hypothesized that CESM is more accurate in lesion detection and size assessment than digital MG and that it is not inferior to MRI. Her study has shown that bilateral dual-energy CESM and MRI are superior to MG in breast tumor detection with CESM performing slightly better than MRI. She found the increase in lesion detection using CESM was 17.5 % compared to MG and 2.6 % compared to MRI.

Dromain et al., [20] study, which included 20-patient with malignant findings only in which CESM was done to depict

angiogenesis, 80% of the lesions showed contrast enhancement in CESM.

The study of ***Lewin et al.,*** [21] including 26 women (14 with malignant lesions and 12 with benign lesions). Thirteen subjects had invasive carcinomas, and one subject had ductal carcinoma in situ (DCIS). Twelve of the 13 invasive carcinomas demonstrated enhancement with no false negative results.

Following the same concept, CESM seems to be a promising tool for increasing the sensitivity of mammography.

The results of our study suggest that dual-energy CESM has an important role in detection of recurrent breast cancer mass lesion and its ability to differentiate between positive lesions and benign post-operative findings.

Conclusion:

CESM, then seems to be a promising tool for increasing the sensitivity of mammography, CESM as an adjunct to mammography is expected to improve diagnostic accuracy compared to mammography alone. CESM reduced false positive results. CESM helped in assessment of recurrent breast disease.

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دور التصوير بالأشعه الرقميه للثدي بالصبغه في مابعد الجراحات التحفظية للثدي

-أمنية طارق أحمد ,سحر محمد الفقي - نيفين عبد المنعم شلبي -أمنية مختار ندا -ميرهان أحمد نصر

الخلفية: يعتبر التصوير بالأشعة الرقمية للثدي بالصبغة تطورا حديثا من التصوير بالأشعة الرقمية باستخدام الحقن الوريدي للصبغة بالتزامن مع اجراء فحص التصوير الشعاعي للثدي وذلك للكشف عن التجمع الشاذ للصبغة عن طريق رسم خريطة لتوزيع اتساع الأوعية الدموية الناجمة عن السرطان. يتم عمل التصوير بالأشعة الرقمية للثدي بعد العلاج التحفظي للتأكد من استئصال الورم ،للتعرف على التجمعات ما بعد التداخلات العلاجية ،للكشف عن الأورام المتبقية وارتجاع الأورام فيما بعد العلاج الجراحي التحفظي للورم الأولي.

الهدف من الدراسة: تهدف هذه الدراسة إلى توضيح الدور المتنامى للتصوير بالأشعه الرقمية للثدي بالصبغه في إصابات الثدي مابعد الجراحات التحفظية.

المرضى وطرق البحث: أجريت هذه الدراسة علي اربع وخمسين مريضة من مرضى تورم الثدي بمعهد الأورام القومي , جامعة القاهرة واللاتي أجريت لهن جراحات تحفظية وتم تطبيق التصوير بالأشعة الرقمية للثدي بالصبغة علي جميع الحالات ومقارنة نتائجها بنتائج فحص الأنسجة (الفحص الباثولوجي).

النتائج: التصوير بالأشعة الرقمية للثدي بالصبغة هو وسيلة واعدة لزيادة حساسية الفحص بلأشعة الرقمية للثدي فمن المتوقع أن تترفع الدقة التشخيصية له مقارنة به كفحص منفرد.

الخلاصة: إن الفحص بالأشعة الرقمية بالصبغة قلل من النتائج الإيجابية غير الدقيقة مما ساعد في تقييم أورام الثدي المرتجعة بكفاءة أعلى.