INTRODUCTION

Mammography and breast sonography are currently the preferred modalities for screening and diagnosing breast cancers. On mammography, breast composition is classified into four types as defined by the Breast Imaging Reporting and Data System (BI-RADS) (1). Increased breast composition not only impairs the detection of breast lesions, but it also has been considered as a risk factor of breast cancer (2). Breast sonography is useful for evaluation of masses or asymmetries. There are several studies that investigated the sonographic findings for differentiating benign breast lesions from malignant breast lesions.

With the increasing use of chest computed tomography (CT) in a variety of diagnostic pathways, breast abnormalities are being identified more frequently on chest CT (3). It is important that radiologists should not overlook breast lesions on chest CT and they should be aware of CT appearances of malignant and benign breast lesions (4).

In a previous study, chest CT showed a higher interreader agreement for readings of breast composition as compared to mammography (5).

Purpose: To investigate the capability of enhanced chest computed tomography (CT) for detecting breast abnormalities and to assess the influence of breast composition on this detectability.

Materials and Methods: From 2000 to 2013, 75 patients who underwent mammography, breast sonography, and enhanced chest CT within one month and had abnormalities on sonography were included. Detection rate of breast abnormality on enhanced chest CT was compared among 4 types of breast composition by the Breast Imaging Reporting and Data System. Contribution of breast composition, size and enhancement of target lesions to detectability of enhanced chest CT was assessed using logistic regression and chi-square test.

Results: Of the 75 target lesions, 34 (45.3%) were detected on enhanced chest CT, corresponding with those on breast sonography; there were no significantly different detection rates among the 4 types of breast composition (p = 0.078). Breast composition (odds ratio [OR] = 1.07, p = 0.206) and enhancement (OR = 21.49, p = 0.998) had no significant effect, but size (OR = 1.23, p = 0.004) was a significant contributing factor influencing the detectability of enhanced chest CT for breast lesions.

Conclusion: About half of the cases (45.3%) demonstrated breast lesions on chest CT corresponding with target lesions on sonography. Breast composition defined on mammography did not affect the detectability of enhanced chest CT for breast lesions.
mography and breast composition on chest CT might provide additional information for predicting risk of breast cancers (5).

The purpose of our study is to investigate the capability of enhanced chest CT for detecting breast abnormalities and to assess the influence of breast composition on this detectability. Moreover, we tried to evaluate the CT features helpful in differentiating malignant breast lesions from benign breast lesions.

MATERIALS AND METHODS

The Institutional Review Board of our institution did not require any approval or informed patient consent for this type of retrospective study.

Patient Population

From January 2000 to December 2013, we retrospectively identified 983 patients who underwent mammography, breast sonography, and enhanced chest CT within one month at a tertiary medical center. Patients with known breast cancer and a history of surgery for breast cancer were excluded. Finally, 75 women (age range, 35–80 years; mean age, 53.6 years), who had abnormalities on breast sonography, were included in this study.

Clinical indications for enhanced chest CT in these 75 patients included health screening (n = 35), staging work-up for non-pulmonary malignancies (n = 18), various manifestations such as fever, dyspnea, and chest pain (n = 14), abnormality on plain radiography (n = 6), and evaluation of pulmonary neoplasms (n = 2).

Imaging Technique

CT scans were acquired using a multi-detector CT system (Somatom Sensation 64 or dual-source Flash 128 multi-detector CT system, Siemens Medical Solutions, Erlangen, Germany). Scanning was performed from the lower part of the neck to the level of the middle portion of kidneys. Scanning was performed after IV administration of contrast medium (140 mL Iopamidol, Pamiray 300, Dongkook Pharm., Seoul, Korea) with a power injector (Mallinckrodt, Tyco and Vistron CT, Medrad, Arrendale, PA, USA) at an injection rate of 2.5 mL/sec. The scanning parameters were 120 kVp; 90–150 mA; tube rotation time, 0.5 seconds; pitch 1.2.

Breast sonography was performed with a sonographic unit (Acuson Antares, Siemens Medical Solutions, Inc., Malvern, PA, USA) using a standard 5–13 MHz linear array transducer by radiologists who had breast sonography experience ranging from 2–3 years (including reader 1–4).

All patients in this study underwent two-view mammography (both craniocaudal and mediolateral oblique views) of both breasts by a mammography unit (Affinity, Lorad/Hologic Company, Danbury, CT, USA) with the film-screen system (Carestream CR reader, Kodak DirectView, Rochester, NY, USA).

Image Review

All mammography and breast sonography examinations were retrospectively reviewed in consensus by two radiologists (reader 1, 2) who had two and three years of experience. On breast sonography, the reviewers (reader 1, 2) selected the largest lesion as the target lesion in each patient and described the largest diameter, location and BI-RADS assessment categories; category 0 corresponds to an incomplete result with need for additional imaging evaluation; category 1, corresponds to a negative finding; category 2, corresponds to a benign finding; category 3, corresponds to a probably benign finding; category 4, corresponds to a suspicious result ranging from low suspicion to high suspicion for malignancy; category 5, corresponds to a result that is highly suggestive of malignancy; and category 6, corresponds to the result of known biopsy-proven malignancy (1). The readers categorized breast composition on mammography. According to breast composition descriptors of the BI-RADS 5th edition, type a indicates that the breasts are almost entirely fatty. Types b and c indicate that there are scattered areas of fibroglandular density and breasts are heterogeneously dense, respectively. Type d indicates that breasts are extremely dense (1). Breast composition was also divided into dense (c and d) and non-dense (a and b) types. Moreover, they identified lesions, such as focal asymmetries or masses, and determined detection of breast lesions on mammography, according to whether there were corresponding lesions on breast sonography.

The other two radiologists (reader 3, 4) who had four and eight years of experience interpreted all enhanced chest CT examinations in consensus. They reviewed the unenhanced and contrast-enhanced CT scans to determine whether breast lesions, corresponding to the target lesions on breast sonography, could be seen. They knew about the presence of breast lesions on sonography, but they were blinded to their location and size. The readers
selected the largest lesion in each chest CT scan as the target lesion and described its location and size; the largest diameter on an axial image, shape; oval, round, and irregular, margin; circumscribed or not circumscribed, and presence or absence of enhancement; enhancement indicated a more conspicuous lesion on enhanced CT images compared with unenhanced CT images. Then, one of the reviewers (reader 3) compared the target lesions on chest CT with those on breast sonography, and decided the detection of breast lesions on chest CT according to whether target lesions on enhanced chest CT corresponded with those on breast sonography. They also evaluated the presence or absence of axillary adenopathy and skin change, such as skin thickening or retraction of the involved breast (Figs. 1, 2).

Statistical Analysis

In evaluation of detectability of chest CT and mammography, differences according to the BI-RADS type of breast composition as well as the two types of breast composition were analyzed by chi-square test. Logistic regression was conducted to assess the contribution of the two types of breast composition and size and enhancement of target lesions to detectability of enhanced chest CT.

We compared the differences in CT morphology between benign and malignant breast lesions by the t-test for continuous variables or chi-square test for categorical variables. A p-value of less than 0.05 was considered to indicate statistical significance.

RESULTS

Detectability of Mammography and Enhanced Chest CT

The type of breast composition on mammography was as follows: type a (n = 4), type b (n = 11), type c (n = 38), and type d (n = 22). On mammography, 9 (12.0%) lesions, corresponding with the target lesions on breast sonography, were detected; breast composition type a (n = 0), type b (n = 1), type c (n = 4), and type d (n = 4). BI-RADS assessment categories for these 9 lesions identified on mammography consisted of category 0 (n = 3), category 1 (n = 0), category 2 (n = 1), category 3 (n = 1), category 4 (n = 2), and category 5 (n = 2). There was no significant difference in the detection rate on mammography, according to the breast composition type in chi-square test (p = 0.680) (Table 1).

A total of 75 target lesions on breast sonography were classified as BI-RADS assessment category 2 (n = 6), category 3 (n = 47), category 4 (n = 19), and category 5 (n = 3).

Of the 75 target lesions, 34 (45.3%) lesions were detected on enhanced chest CT which corresponded with the target lesions on breast sonography; breast composition type a (n = 0), type b (n = 4), type c (n = 16), and type d (n = 14). Of the 34 lesions on enhanced chest CT, 15 lesions were foci with size less than 2 mm and the remaining 19 lesions showed a mean size of 8.9 mm (range 4–54 mm). Among the 19 lesions with size more than 2 mm, the shapes were oval (n = 4), round (n = 10), and irregular (n = 5) and the margins were circumscribed (n = 12) and non-circumscribed (n = 7). In contrast-enhanced CT scans, presence or absence of enhancement in a total of 34 lesions was as follows: presence (n = 15) and absence (n = 19). Associated features were axillary adenopathy (n = 5) and skin change (n = 3).

There was no significant difference in detectability of breast lesions on chest CT, according to the four types of breast composition in chi-square test (p = 0.078) (Table 1). In logistic regression analysis, two types of breast composition (dense and non-dense types) had no significant effect on detectability of breast lesions on chest CT [odds ratio (OR) = 1.07, p = 0.206]. Lesion size was a significant contributing factor for detectability of breast lesions on chest CT (OR = 1.23, p = 0.004). OR of enhancement (21.49) was very high, but there was no statistical significance (p = 0.998) (Table 2).

CT Morphologic Features of Malignant and Benign Breast Lesions

Of the 75 patients, 8 showed breast carcinoma through sonography-guided needle biopsy and 32 had benign breast diseases, which consisted of 19 pathologically proven lesions and 13 benign lesions categorized on breast sonography at the time of investigation or follow up. In the remaining 35 patients, there were no medical records of further evaluation for breast abnormalities.

Of the 40 cases including 8 cases of malignant breast diseases and 32 cases of benign breast diseases, the morphologic features of breast lesions on enhanced chest CT were compared between benign and malignant lesions (Table 3). The mean size was significantly different between benign and malignant breast lesions (8.8 ± 4.0 and 21.5 ± 17.5, respectively; p = 0.018). The irregular shape (0% vs. 100%, p = 0.023) and non-circumscribed margin
(28.6 % vs. 71.4%, \( p = 0.031 \)) were more frequently observed features in malignant lesions than in benign lesions. Axillary adenopathy (20% vs. 80%, \( p = 0.006 \)) and skin change (0% vs. 100%, \( p = 0.005 \)) appeared more frequently in malignant breast lesions than in benign breast lesions.

![Image](image1.png)

**Fig. 1.** 57-year-old woman with invasive ductal carcinoma diagnosed through sonography-guided needle biopsy.

A. Craniocaudal mammography of the left breast shows heterogeneously dense breast and it is classified as breast composition type c. There is a high density mass with irregular shape, indistinct margin, fine pleomorphic calcification (arrows).

B. Contrast-enhanced chest CT shows about 53 mm sized enhancing mass in the left breast which is irregular shaped with lobulated margin. Associated skin thickening is also noted.

C. US image shows a corresponding about 50 mm sized mass in the lower medial portion of left breast which is hypoechoic irregular mass with a heterogeneous internal echo pattern and classified as BI-RADS assessment category 5.

BI-RADS = Breast Imaging Reporting and Data System, US = ultrasonography

![Image](image2.png)

**Fig. 2.** 42-year-old woman with fibroadenoma diagnosed through vacuum assisted biopsy.

A. Craniocaudal mammography of the right breast shows extremely dense breast and it is classified as breast composition type d. There is no evidence of mass nor suspicious morphology of calcification.

B. Contrast-enhanced chest CT shows a subcentimetered oval shaped enhancing mass with smooth margin in the right breast (arrow).

C. US image shows a corresponding 9 mm sized mass in the upper outer portion of right breast which is well circumscribed oval hypoechoic mass with parallel orientation and classified as BI-RADS assessment category 3.

BI-RADS = Breast Imaging Reporting and Data System, US = ultrasonography

![Table](table1.png)

**Table 1. Detectability of Breast Lesions on Chest CT and Mammography, according to Types of Breast Composition**

|                      | Type a | Type b | Type c | Type d | \( p \)-Value |
|----------------------|--------|--------|--------|--------|--------------|
| Breast lesions on chest CT |        |        |        |        |              |
| Absence              | 4      | 7      | 22     | 8      |              |
| Presence             | 0      | 4      | 16     | 14     |              |
| Detection rate (%)   | 0.0    | 36.4   | 42.1   | 63.6   | 0.078        |
| Breast lesions on mammography |        |        |        |        |              |
| Absence              | 4      | 10     | 34     | 18     |              |
| Presence             | 0      | 1      | 4      | 4      |              |
| Detection rate (%)   | 0.0    | 9.0    | 10.5   | 18.2   | 0.680        |
DISCUSSION

We investigated the capability of enhanced chest CT to detect breast lesions in patients who had abnormalities on breast sonography. The detection rate of mammography has been evaluated in previous studies and it demonstrated a wide range from 68% to 88% (6). Kim et al. (7) reported that 86% of breast lesions were incidentally detected on chest CT and they correlated with breast sonography. On the other hand, in our study, a total of 75 patients with breast abnormalities on sonography were enrolled, and of them, about half of the cases (45.3%) demonstrated breast lesions on enhanced chest CT which corresponded to the target lesions on breast sonography. Breast lesions were not incidentally detected, but the readers, who knew about the presence of breast lesions and were blinded to their location and size, selected the breast lesions on chest CT scan which corresponded with those on breast sonography.

There are several studies in which the effect of breast composition on mammographic performance was evaluated (6, 8). Although in our study there was no significant difference in the detection rate among types of breast composition, which is because a very small number of lesions were detected on mammography, in analysis of 27825 patients by Kolb et al. (6), they concluded that the sensitivity of mammography declined significantly with increasing breast composition. For enhanced chest CT scans, our results did not show two types (dense and non-dense) of breast composition or that the four types of breast composition had a significant effect on detectability of breast lesions. This might have resulted from the fact that, as a cross-sectional image, chest CT eliminates summation artifact and superimposition of glandular tissues.

Breast composition on mammography is a risk factor for breast cancer, as well as it affects mammographic performance (9, 10). This has also been known that supplemental breast sonography can aid in detection of breast cancers in women with dense breasts (11). In our study, about half of the cases with breast abnormalities were identified on enhanced chest CT. Thus for women who undergo only chest CT, it may provide information on breast lesions and further evaluations including mammography or breast sonography can be suggested, especially in high risk patients.

It is known that the features favoring a benign lesion on breast sonography were oval shape, parallel orientation to the skin, circumscribed margin, abrupt boundary, and anechoic and hyper-echoic pattern. On the other hand, malignant features on breast sonography were irregular and round shape, non-parallel orientation, microlobulated, indistinct, angular, or spiculated margin, and boundary of echogenic halo (12-15). There are several studies which reported the CT features of incidental breast lesions suggestive of malignancy, including irregular or spiculated mar-

| Features          | Benign Lesions (n = 32) | Malignant Lesions (n = 8) | p-Value |
|-------------------|-------------------------|---------------------------|---------|
| Size (mm)         | 8.8                     | 21.5                      | 0.018   |
| Shape             |                         |                           | 0.023   |
| Round             | 5 (83.3)                | 1 (16.7)                  |         |
| Oval              | 3 (75)                  | 1 (25)                    |         |
| Irregular         | 0 (0)                   | 4 (100)                   |         |
| Margin            |                         |                           | 0.031   |
| Circumscribed     | 6 (85.7)                | 1 (14.3)                  |         |
| Not circumscribed | 2 (28.6)                | 5 (71.4)                  |         |
| Enhancement       |                         |                           | 0.646   |
| Presence          | 4 (57.1)                | 3 (42.9)                  |         |
| Absence           | 1 (100)                 | 0 (0)                     |         |
| Axillary lymph node | 1 (20)                 | 4 (80)                    | 0.006   |
| Skin thickening   | 0 (0)                   | 3 (100)                   | 0.005   |

Data are the numbers of patients. Numbers in parentheses are percentages.
gins, irregular shape, and rim enhancement. A washout pattern on postcontrast images and diffuse regional enhancement had high positive predictive values for malignancy (16-19). Similarly, in our study, malignant breast lesions were more irregular in shape and they demonstrated a non-circumscribed margin more frequently, compared with benign lesions \((p = 0.023 \text{ and } 0.031)\). But the difference in enhancement between malignant and benign lesions was not significant \((p = 0.646)\).

March et al. (20) studied 35 patients of breast cancer for evaluating detection of axillary lymph nodes on preoperative chest CT scan. They reported a positive predictive value of 89%. Another study concluded that chest CT in prone position with 5 mm sections accurately predicted axillary lymph node involvement in breast cancer (21). Results of our study correlated with conclusions of these studies. In our study, additional findings such as axillary lymphadenopathy \((p = 0.006)\) and skin thickening \((p = 0.005)\) were more frequently observed in malignant breast lesions.

There are several limitations in our study; first, the small study population and the retrospective nature of the study design may have reduced the power of this study. Contrast-enhanced chest CT for a variety of indications may be less sensitive than dedicated breast CT in detecting and characterizing breast lesions (22). Also various types of CT acquisition and injection protocols were used during the period. Therefore, delayed-phase scanning time may not have been standardized. It was limited to detect breast tumors and measure the accurate size of tumors, because breasts were compressed by gravity in the supine position. Another limitation was that there might be a discrepancy between the target lesions on chest CT and breast sonography, although we compared each of the lesions with their location and size. Because we did not consider all lesions on breast sonography, but we only considered the largest lesions, it may have influenced the detectability of breast lesions on chest CT.

Our study suggested that about half of the cases (45.3%) demonstrated breast lesions on enhanced chest CT which corresponded with target lesions on sonography. Also, breast composition defined on mammography did not affect the detectability of enhanced chest CT for breast lesions. Therefore, cautious interpretation of enhanced chest CT might help detect breast abnormalities covered with dense parenchyma.

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조영증강 흉부단층촬영검사에서 유방 병변의 발견:
유방 실질의 구성과의 연관성

조은미 · 강희·신영형·윤종혁·오경승·박세경

목적: 조영증강 흉부 전산화단층촬영에서 유방 병변의 발견율과 이에 대해 유방 실질의 밀도가 영향을 미치는지를 알아보고자 하였다.

대상과 방법: 한 달 이내에 유방 초음파와 단순유방촬영, 조영증강 흉부 전산화단층촬영을 모두 시행 받은 환자 중 유방 초음파에서 병변이 발견된 환자를 대상으로 하였다. 단순유방촬영에서 Breast Imaging Reporting and Data System에 의해 정의된 4 유형의 유방 실질의 구성에서 흉부단층촬영상 유방 병변의 발견 빈도를 비교하였다. 유방 실질의 밀도와 유방 초음파상 병변의 크기, 조영증강 여부가 유방 병변의 발견율에 어떤 영향을 미치는지 카이 제곱 검정과 로지스틱 회귀 분석을 통해 알아보았다.

결과: 총 75명의 환자 중 34명(45.3%)에서 유방초음파에서 확인된 병변과 일치하는 병변이 흉부단층촬영에서 발견되었으며 4 유형의 유방 실질의 밀도에 따라 발견율의 유의한 차이가 없었다(p = 0.078). 로지스틱 회귀 분석 결과 유방 실질의 밀도[odds ratio (이하 OR) = 1.07, p = 0.206]와 조영증강 여부[OR = 21.49, p = 0.998]는 흉부단층촬영에서 유방 병변의 발견율에 유의한 영향을 미치지 않았으며 병변의 크기[OR = 1.23, p = 0.004]는 통계적으로 유의한 기여 인자로 나타났다.

결론: 조영증강 흉부 전산화단층촬영상 45.3%에서 초음파에 상응하는 유방 병변을 관찰할 수 있었으며 유방 실질의 밀도는 발견율에 유의한 영향을 미치지 않았다.

고신대학교 의과대학 고신대학교복음병원 영상의학과