B6－4

A Quantitative Radiographic Index of Breast "Density" Based on a Density Histogram of a Mammogram

Keiko Imamura[1], Haruki Ogata[2], Kaoru Sasaka[1], Mamoru Fukuda[2], Norishige Ehara[1], Yasuo Nakajima[1], & Yoshiharu Higashida[3]
[1] Departments of Radiology, & [2] Surgery, St. Marianna University School Medicine,
[3] Kyushu University School of Health Sciences

INTRODUCTION

Breast masses can be detected clearly on a mammogram if they appeared in a fat tissue or if the optical density of the mammogram were relatively high as a whole. The diagnostic capability of mammography, therefore, is correlated with radiographic density pattern of a mammogram. Breast with the high content of parenchymal tissue, when giving a mammogram of low optical density, is called a "dense breast".

"Dense breast" results from the X-ray exposure technique as well as the nature of the breast itself. With the development of mammography-dedicated film/screen system of high film gradient, incidence of mammograms classified into "dense breast" seems to be reduced when the radiographed using appropriate X-ray exposure.

As "dense breast" is a category classified by visual evaluation, we investigated in this study the density patterns of mammograms with the purpose to get a quantitative index of breast density on a mammogram.

MATERIALS AND METHODS

Analyzed were 80 mammograms obtained by screen/film system in 40 patients; 10 mammograms in each category of Wolfe's classification, N1, P1, P2 and DY [1]. Those images were classified by surgeons (H. O. and M. F.).

Films were digitized using a digitizer, VXR-12 *plus* (VIDAR Systems Co.), with the spatial resolution of 150 DPI (170 μm) and density resolution of 8 bits/pixel [2]. Digitized images were saved on TIFF format without compression. To analyze density pattern, histogram of pixel values of the whole breast was obtained using an NIH Image (National Institutes of Health, USA) on a Macintosh computer. To define the region-for-analysis, the margin of breast was identified in a manual way.

The histogram data was exported to EXCEL (Microsoft Co.). To specify the pattern of histogram, pixel values ranging from zero to 255 on 8-bit digitization were divided to four density components in this study. The criterion of components were given so as to be consistent with the description in terms of optical density; 115, 145, and 175 on 8-bit scale, corresponding to optical film density 1.0, 1.2, and 1.4, respectively. Component A includes pixel value smaller than 114, B 115 to 144, C 145 to 174, and D greater than 175.

The counted number of pixels included in each density component can be taken as the area in the breast of

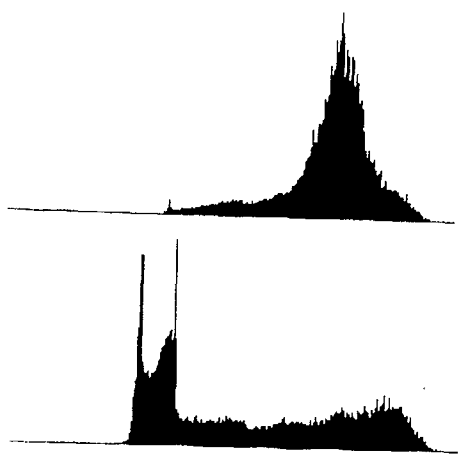

Fig. 1 Histogram of pixel values of mammograms grouped to N1 (upper) and DY (lower) in Wolfe's classification [1]. Pixel values are on abscissa, ranging from zero on the left and 255 on the right.

corresponding density. It was evaluated relatively to the whole number of pixels in a histogram.

RESULTS

The histograms of pixel values of the whole breast are compared in Fig. 1 for N1 and DY breasts. Fig. 2 shows the relative area of each density component for mammograms categorized into N1, P1, P2 and DY. Relative area decreased with the decrease of optical density in mammogram groups of N1, P1, and P2, and the patterns of P1 and P2 groups are close to each other. On the other hand, distribution of relative areas of DY group was rather different from other three groups.

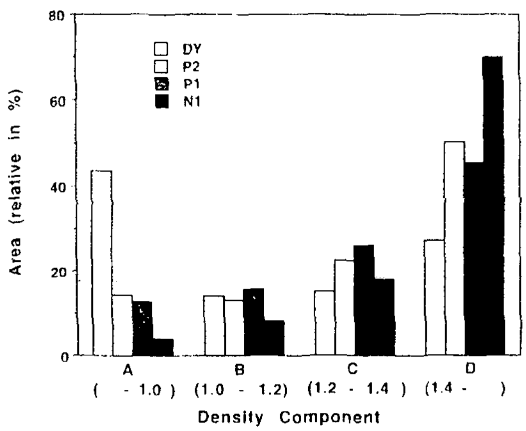

Fig. 2 Area of each density component of the breasts.
DY, P2, P1 and N1 are Wolfe's classification of mammograms.

DISCUSSION AND CONCLUSIONS

Mammograms categorized into the same Wolfe's classification group had a variation in their density characteristic because of the ambiguity in the visual perception among observers and even in one observer.

As described in INTRODUCTION, a unified quantitative index is needed to describe density characteristic of a mammogram. In Wolfe's classification, N1 and DY are extreme groups with high and low optical density, respectively. If the representative density characteristic was determined for DY group and for N1 group as a baseline, density characteristic of any mammogram could be measured as the distance to DY group. Assuming the linearity of change between N1 and DY groups, one of the possible model of the distance from a mammogram under investigation to DY could be

$$\sum_{i=1}^{n} ((X(i) - N(i))) / (D(i) - N(i))) / n,$$

where n is the number of density components on a histogram, which is 4 (A, B, C, and D) in this study, N and D indicate N1 and DY groups, respectively. X is a mammogram to be evaluated. D(A) is, for example, a relative area of the density component A in DY group, as can be seen in Fig. 2.

That kind of "Density Index", as defined above, quantifies the radiographic density pattern of a mammogram and, and can be applied to the study of diagnostic statistics and could be extended to quality control with a focus to get appropriate X-ray exposure.

REFERENCES

1. Wolfe JN. Risk for breast cancer development determined by mammographic parenchymal pattern. Cancer 37: 2486 - 2492, 1976.
2. Imamura K, et al. Quantitative evaluation of phantom images for mammography quality control. CAR '98 (eds. Lemke HU, et al.), 15 - 20, Elsevier Science, 1998.