SHORT COMMUNICATION

Ultrasound for Accurate Measurement of Invasive Breast Cancer Tumor Size

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Abstract: Accurate presurgical assessment of tumor size is important for choosing appropriate treatment, especially with the increasing use of neoadjuvant and minimally invasive therapy. Breast sonography is increasingly used by breast surgeons as a part of their basic clinical evaluation. We undertook this study to compare clinical evaluation, mammography, and breast sonography for evaluating breast tumor size. A prospective analysis of 124 consecutive patients with palpable breast cancer was performed. Tumor masses belonging to T1 and small T2 were selectively selected. All women had clinical, mammographic, and sonographic assessment of tumor size. Measurements were compared to the pathologic tumor size of the surgical specimen. Both mammographic and sonographic measurements tend to underestimate tumor size, while clinical assessment tends to overestimate it. Ultrasound was significantly more accurate in determining tumor size. The maximal tumor diameter measured was within 2 mm of the pathologic tumor size in 45.2% of cases measured by breast ultrasound, 28.2% of cases measured by mammography, and 14.5% of cases measured clinically. These data suggest that ultrasound is more accurate than clinical breast examination and mammography in assessing breast cancer size. Ultrasound assessment should be used by surgeons as an accurate adjunct to clinical examination in outpatient breast clinics.

Key Words: breast cancer, breast ultrasonography, tumor size

Accurate assessment of breast cancer size is important as a determinant of primary therapeutic options and as a prognostic indicator. Today many operable breast cancer patients are offered primary medical therapy preoperatively. This principally depends on the tumor size at presentation (1). Patients who respond well to primary medical treatment may avoid the need for a mastectomy with successful downsizing of the original cancer size at presentation by chemotherapy or endocrine therapy (2,3).

The ability to accurately and reliably measure the size of the breast cancer prior to any surgical treatment or primary medical therapy is essential. Downsizing of the tumor after neoadjuvant chemotherapy or endocrine therapy leads to loss of the most important prognostic factor, the pathologic tumor size. So accurate measurement by clinical or imaging assessment is fundamental to ensure consistency of the staging and treatment modality, as well as to provide measurable data for research (4).

Because of the limited resources available for screening programs in our locality, most of the breast cancer cases are diagnosed as an infiltrating cancer with a low incidence of ductal carcinoma in situ (DCIS). Using the basic available tools to measure the invasive tumor size is critical in decision making and planning for management.

Tumor size is commonly measured by palpation, but this method varies among observers, is influenced by many factors such as skin thickness, edema, and obesity (5,6), and is prone to overestimation of tumor size (7). Mammography is more accurate than palpation; however, estimates of tumor size vary with the distance between the tumor and the film, and the measurement is usually taken in standard projections that do not necessarily express the largest dimension (6,7). Ultrasound measurement of tumor size is considered a more accurate imaging modality (7). The goal of this study was to compare the accuracy of clinical assessment, mammographic, and ultrasound measurement of breast cancers in predicting the pathologic tumor size in a prospective series of symptomatic patients.

PATIENTS AND METHODS

Between April 2000 and April 2003, 162 consecutive patients with palpable breast cancers presented to the outpatient clinic of Mansoura University Hospital. Of these, 13 patients were selected for preoperative primary medical treatment for different reasons and were excluded from...
the study. Patients were also excluded from the study if they had recurrent tumors, incisional biopsies, or if endocrine therapy had been concomitantly started prior to referral. Patients with multifocal diseases were also not included, as surgical decision making in that cohort may have been independent of tumor size. Eleven patients were also excluded because their tumor size exceeded 38 mm (the diameter of the ultrasound transducer used in this study), so all patients had T1 and small T2 masses. Three patients were excluded because of a delay between sonography and tumor excision of more than 1 month. This resulted in 124 patients in which a wide local excision or mastectomy was performed.

Clinical, mammographic, and ultrasound assessments of the tumor size were performed prior to any invasive investigation such as needle aspiration or tissue biopsy. All tumors were measured clinically, mammographically, and sonographically. The maximum dimension for each modality was compared with the largest pathologic dimension of fresh surgical specimen.

Clinical Breast Examination

Examination of the breast was done by the same surgeon in all cases. All tumors were measured in two dimensions between two fingers (Fig. 1). The larger diameter was used as the clinical tumor size.

Mammography

Mammography was performed using dedicated mammographic equipment using standard craniocaudal and mediolateral oblique projections. The largest dimension was determined from these views with a ruler (Fig. 2).

Sonography

All breast sonographic evaluations were performed by a surgeon with experience in breast sonography. All lesions were studied with a LOGIQ 200 Pro ultrasound scanner (GE Medical Systems) using a linear array transducer with a central frequency of 6.6 MHz and a broadband frequency (5.2–11.3 MHz) of reception. The probe was held orthogonal to the skin and the two largest diameters of the tumor were measured with the machine’s electronic calipers and recorded on the static images (results were rounded up to the nearest millimeter). For measurement purposes, the tumor edge was defined as the end of the hypoechoic mass before the wide border denoting the transition between the tumor and the healthy surrounding tissue (Fig. 3).

Pathology

The resected tumors were measured in millimeters in two dimensions with a calibrated rule before being fixed in formalin (Fig. 4). Tumor size was also measured in histologic sections. Only the largest dimension obtained by either method was used.

Statistical Analysis

To assess the agreement between the three methods of tumor size measurement, data were presented and analyzed...
using methods described by Bland and Altman (8). Histopathologic size was plotted against the clinically measured, mammographic, or ultrasonographic dimensions and compared to the line of unity (8). Clinical assessment, mammographic, and ultrasonographic measurements of preoperative cancer size were each compared with the pathologic size using McNamara’s test. The agreement between the different modalities was analyzed.

RESULTS

The mean patient age in this series was 52 years (range 31–73 years). Of the 124 cancers, 105 (84.7%) were invasive ductal, 12 (9.7%) were invasive lobular, 5 (4%) were mixed ductal and lobular cancer, and 2 (1.6%) were palpable DCIS. The mean pathologic tumor size was 28.8 mm (range 8–38 mm).

Overall, while clinical breast examination tended to overestimate the size of the tumor, both imaging modalities tended to underestimate tumor size (Table 1). In 89 cases (71.8%), ultrasound was better than mammography in determining the maximum tumor diameter. In 101 cases (81.5%), ultrasound was better than clinical breast examination in determining the maximum tumor diameter. Ultrasound underestimated tumor size by at least 1 mm in 65% of the cases. The mean underestimation of tumor size by ultrasound was 3.2 ± 0.4 mm. The maximal tumor diameter as assessed by ultrasound was within 2 mm of the pathologic tumor size in 45.2% of cases, within 5 mm in 79.8% of cases, and within 10 mm in 91.9% of cases.

Mammography underestimated tumor size by at least 1 mm in 57.3% of the cases. The mean underestimation of tumor size by mammography was 4 ± 0.9 mm. The mammographically determined tumor size was accurate to within 2 mm of pathologic size in 28.2% of cases, within 5 mm in 62.1% of cases, and within 10 mm in 82.3% of cases.

On the other hand, clinical breast examination tended to overestimate the tumor size by at least 1 mm in 69.4% of cases. The mean overestimation of tumor size by clinical breast examination was 8 ± 0.6 mm. The clinically determined tumor size was accurate to within 2 mm of pathologic size in 14.5% of cases, within 5 mm in 41.1% of cases, and within 10 mm in 73.4% of cases.

Table 2 shows the percentage of cases measured by each modality as closer to the pathologic tumor size.

The correlation coefficient for sonographic determination of maximal tumor dimension with pathologic size was 0.66, with a standard error of 0.71 and a p-value of
less than 0.0001. The correlation coefficient for mammographic determination of maximal tumor dimension with pathologic size was 0.42, with a standard error of 0.89 and a p-value of less than 0.0001. The correlation coefficient for clinical determination of maximal tumor dimension with pathologic size was 0.35, with a standard error of 0.9 and a p-value of less than 0.0001. Scatter plots showing histopathologic size plotted against the clinically measured, mammographic, or ultrasonographic dimensions and compared to the line of unity are shown in Figures 5–7.

The ability of ultrasound to measure tumors was not significantly dependent upon tumor histology (infiltrating ductal versus infiltrating lobular). The numbers of mixed carcinoma and DCIS cases were too few to determine a correlation.

### DISCUSSION

Mammosonography is routinely used in the evaluation of new breast lumps, providing qualitative information in the context of a triple assessment about the lump’s characteristics (9). Symptomatic breast disease is usually investigated in a one-stop clinic, where clinical assessment is used alongside mammosonography and fine-needle aspiration for cytology or core biopsy for tissue diagnosis. Clinical, mammographic, and ultrasonographic measurements of tumor size are routinely recorded as a part of this assessment.

Currently there is no consensus on how best to assess breast cancer size. Ultrasound assessment of tumor size at presentation is considered a more accurate measure of pathologic tumor size compared to clinical measurement. Clinical palpation tends to overestimate tumor size and has the largest standard deviation of the difference, while ultrasound and mammography tend to underestimate tumor size and have a similar standard deviation of the difference (10). Moertal and Hanley (4) elegantly demonstrated the effects of systematic errors in simulated lump clinical assessment, not only between different examiners, but also errors arising from repeated measurements. Our study concurs with previous authors (11,12), that clinicians tend to overestimate the size of breast tumors. Clinical assessment must take into account skin thickness and the depth of the tumor within the breast. In addition, clinicians can only palpate two (length and width) axes of a three-dimensional tumor, compared to ultrasound, which can provide three-dimensional measurement including assessment of tumor depth.

In this study we also found that ultrasound was more accurate than mammography in determining breast cancer size. Table 3 summarizes the data from published studies comparing sonography and mammography for assessing

### Table 2. The Measured Tumor Size Compared to the Pathologic Tumor Size

| To pathologic tumor size | Clinical breast examination | Mammography | Ultrasonography |
|-------------------------|----------------------------|-------------|-----------------|
| Accurate within 2 mm    | 14.5%                      | 28.2%       | 45.2%           |
| Accurate within 5 mm    | 41.1%                      | 62.1%       | 79.8%           |
| Accurate within 10 mm   | 73.4%                      | 82.3%       | 91.9%           |
Table 3. Correlation of Maximum Breast Cancer Diameter by Ultrasonography and Mammography with Pathologic Tumor Measurement

| Investigator | Imaging modality | No. of patients | Correlation coefficient | Standard error |
|--------------|------------------|-----------------|-------------------------|----------------|
| 7            | Sonography       | 31              | 0.84                    | 0.38           |
|              | Mammography      | 20              | 0.72                    | 0.42           |
| 6            | Sonography       | 52              | 0.89                    | Not given      |
|              | Mammography      | 45              | 0.84                    | Not given      |
| 15           | Sonography       | 38              | 0.93                    | 0.62           |
|              | Mammography      | 35              | 0.84                    | 0.95           |
| 16           | Sonography       | 70              | 0.69                    | Not given      |
|              | Mammography      | 70              | 0.69                    | Not given      |
| 17           | Sonography       | 146             | 0.63                    | 0.74           |
|              | Mammography      | 146             | 0.40                    | 0.89           |

preoperative maximal tumor diameter. Our data are in line with these results, which show that ultrasound is more accurate. Ultrasonography is also essential for staging tumors invisible on a mammogram. Ultrasound can also be applied to patients with dense breasts in whom mammography may be suboptimal or does not reveal the tumor at all.

Although our results show that the ability of ultrasound to measure tumors was not significantly dependent upon tumor histology, we believe that this point has to be studied more intensively, especially because of our low incidence of breast carcinoma in situ cases (owing to the lack of a screening program) and the small number of infiltrating lobular carcinoma cases.

Ultrasound performed in outpatients by a breast surgeon is an accurate and useful adjunct to clinical assessment. This enables rapid diagnosis in one-stop breast clinics (9). Recently there has been a transition from radical local therapy to breast conservation for the treatment of invasive breast cancer. Breast preservation has not adversely affected overall survival in appropriately selected patients. This has generated interest in even less invasive methods for local-regional treatment. Techniques such as laser, radiofrequency, and cryoablation are being investigated (13). These percutaneous methods of eradicating breast tumors rely on accurate sonographic guidance for their efficiency. Even standard breast-conserving therapy for the treatment of nonpalpable tumors requires accurate image-guided localization techniques. All of these techniques are more logically performed by a surgeon rather than a radiologist, and this requires surgeons with excellent experience in breast sonography, especially regarding primary tumor evaluation. The practical involvement by the surgeon in breast ultrasound and performing core biopsies has reduced pressure on breast radiologists, reduced the number of diagnostic surgical open biopsies, and made the clinic more interesting for the surgeon. Trainee breast surgeons should be encouraged to learn breast ultrasound and core biopsies (14).

Ultrasound assessment of breast cancer size is more accurate than both clinical and mammographic assessments. Ultrasound examination of the breast is a noninvasive, accurate, efficient way to evaluate primary tumor size with high patient acceptance. In addition, ultrasound assessment should be used by the surgeon as an accurate adjunct to clinical examination in outpatient breast clinics.

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