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Determination of the breast volume after breast conservating surgery

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A mathematical description has been developed to estimate the difference in volume between the breasts after breast conservating surgery. This method can help the physician to evaluate the cosmetic results after treatment. It is a simple method for the radiotherapist who routinely uses a simulator.

Key words: mastectomy; mammography-methods; breast conservating therapy, cosmetic evaluation, breast volume

Introduction

The patient with a diagnosis of early breast cancer can now be successfully treated by conservative techniques. Studies results have demonstrated that for small tumors (T1 and small T2) lumpectomy followed by radiotherapy is a valid alternative to mastectomy.[1]

Today, the physician tries not only to cure the patient but to achieve the best possible cosmetic results.[2] In the breast the cosmetic outcome is generally evaluated by the difference in size between the two breasts, teleangiectasia and fibrosis.

Measurement of the size of the breast is somewhat subjective. We describe in this paper a more objective method of measuring breast size.

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Method

Theory

Breast is a region bounded by the chest wall on one side and by the skin on the other. This could be schematized by regarding the breast as a segment of a sphere, with the pectoral muscle being a second segment of a sphere within the first. The volume of interest is represented by the difference between the two spherical domes.

The problem can now be resolved mathematically. The common base of the two segments is a circle of radius R. The outer segment is bounded by the skin (height H); the inner segment is defined by the fascia of the pectoral muscle (height h) from the chest wall. The volume of the breast (v) can be assimilated to the difference in volume of these two spherical domes mathematically expressed as:

$$V = \frac{\pi}{6}(H^3 - h^3) + \frac{\pi}{2} R^2 (H - h)$$

However, it appears more suitable to the geometry encountered in most of the patients to consider the base of the segments as elliptical (Figure 1a, 1b).

The maximum and minimum radii need to be defined. The maximum radius is in the transverse axis (R) and the minimum in the cranio caudal axis (r).

We can now use the ratio (r/R) to modify the above equation

$$V = \frac{r}{R}\frac{\pi}{6}(H^3 - h^3) + \frac{\pi}{2}R^2(H - h)$$

V = volume of the breast.
R = half the maximum transverse "width" of the breast.
r = half the maximum cranio caudal "length" of the breast.
H = elevation of the breast.
h = elevation of the chest wall.

We have used this formula to calculate the volume of the breast in this study.

Measurement of the geometrical dimensions of the breast

With the patient in the supine position, using a conformator (or a CT-scan if available), we drew the contours of the thorax including the breast at two different levels.

The first contour C_{Med} is taken at the level of the two nipples, the second at the level of the inframammary fold. The cranio caudal diameter (2 r) of the breast is measured directly on the patient as shown on the picture. The most medial limit (A) and the most lateral limit (B) of the breast tissue are located clinically on the patient and are indicated by the conformator on the median contour (C_{Med}). The "width" (2R) of the breast is equal to the distance AB.

The height H of the external segment of a sphere (to which the breast can be assimilated) is the maximal distance (h) between the median contour C_{Med} and the AB line.

The height of the inner segment of a sphere (to which the chest wall is approximated) can only be estimated, as the conformator cannot trace its contour. We can consider that the maximal distance (h) between the contour C_{Inf} at the level of the inframammary fold and the AB line represents its best approximation and can be easily measured on the drawing.

All the measurements required for the calculation of the volume of the breast are then available.

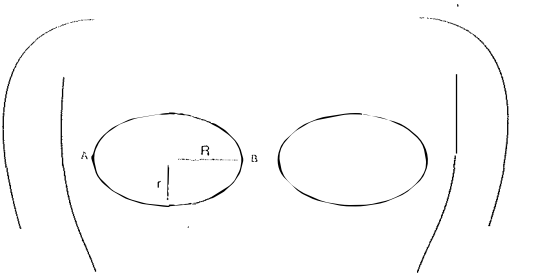

Figure 1a. Representation of the base of the breast as an ellipse of which the great radius R is half the width of the breast and small radius r is half its height.

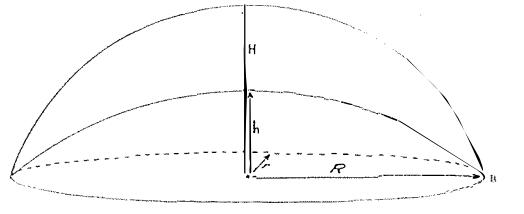

Figure 1b. Representation of the volume of the breast as being the difference between two domed segments of heights H and h and of which the base is an ellipses of radiuses R and r.

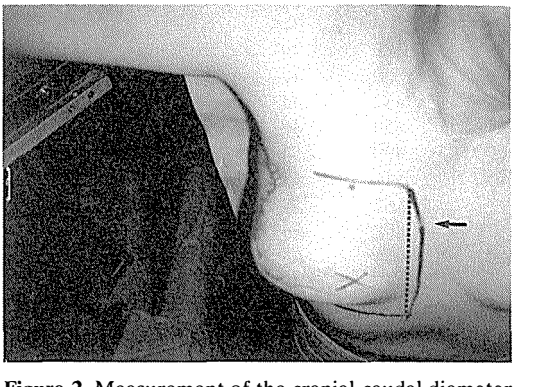

Figure 2. Measurement of the cranial caudal diameter 2 r.

Application

We have measured the volume of the breast of 22 women who had been treated by lumpectomy for breast cancer prior to radiation. Table 1 compares the volumes of the treated breast and of the other breast:

1) the volume of the other breast ranges from 169 cm^3 to 846 cm^3, with an average of 435 cm^3.

2) the volume of the treated breast ranges from 163 cm^3 to 799 cm^3, with an average of 405 cm^3.

3) the difference between the volume of the treated breast and the volume of the other breast ranges from 2% to 27%, due mainly to variation of the difference H-h between treated breast and other breast.

Table 1. Comparison of the volumes of the treated breast and of the other breast.

N° of cases	Volume (cm^3)		Difference in volume between the two breasts	
	Treated breast	Other breast	cm^3	%
1	166	169	3	1,8
2	163	190	27	14,2
3	226	244	18	7,4
4	230	251	21	8,4
5	200	275	75	27,3
6	256	280	24	8,6
7	272	288	16	5,5
8	254	304	50	16,4
9	298	319	21	6,6
10	309	348	39	11,2
11	388	397	9	2,3
12	380	411	31	7,5
13	432	448	16	3,6
14	450	463	13	2,8
15	490	540	50	9,3
16	546	572	26	4,5
17	562	578	16	2,7
18	498	608	110	18
19	604	628	24	3,8
20	647	660	13	2
21	742	763	21	2,75
22	799	846	47	5,5

The same method could be used to measure the difference in volume between the breast as it appears just after radiotherapy and as it becomes after months or years.

The study of a greater number of cases should enable us to establish a correlation between the calculated difference of volume and the qualitative assessment (minor, marked or major difference), and to derive an objective assessment of one of the factors of the aesthetic result of a conservative treatment of breast cancer.

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