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Breast Volume estimation by Anthropometry

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Abstract

Introduction & Objectives: *Breast volume measurement is required for augmentation, reduction and reconstructive oncoplastic breast procedures. Currently no simple, economical and ideal breast volume assessment method exists. We calculated breast volumes by anthropometric methods in fifty patients undergoing modified radical mastectomy, and compared them with their own post-mastectomy specimen volumes taken as controls.*

Material & Methods: *Breast volumes were calculated by Oteify et al formula using breast circumference in supine & upright positions, and by Qiao et al formula using breast radii & mammary projection. Post-mastectomy specimen volume was calculated by Archimedes principle after dividing axillary tissue from the specimen. Results were compared with those of anthropometric formulae and correlated with age, grade of ptosis & bra size.*

Results: *Both formulae gave comparable results up to 300 cc specimen volume, beyond which Qiao et al formula became inaccurate. Otiefy et al formula remained valid till 700 cc. Although all specimen volumes, anthropometric measurements and volume calculations increased with grade of Ptosis, results were most accurate in non-ptotic breasts. Both formulae were comparable up to bra size 32B, but lost accuracy beyond size 36 & cup C/D.*

Conclusion: *Both formulae can assess volume correctly in small to medium sized non-ptotic breasts. But neither formula is valid for large breasts. Grade of Ptosis greatly impacts the accuracy of these anthropometric formulae. Therefore, it should either be eliminated or incorporated in the breast volume calculation methods. However, breast volume measurement by anthropometry was easy, convenient, and without needing any sophisticated equipment, was economical.*

Keywords: *Breast Oncoplasty; Breast Reconstruction; Breast Volume; Anthropometry.*

Introduction

Breasts are a sign of femininity and therefore removal of breast leads to not only cosmetic damage to physical appearance, but also has an adverse psychological impact on the patients. The definition of an ideal breast varies; however, some specific criteria are universally accepted. Proportional size with respect to the body, absence of ptosis, tear-drop shape and anteriorly placed nipples are some of the characteristics of an aesthetic breast [1]. The main goal of aesthetic and reconstructive breast surgery is to achieve these characteristics in a way to produce symmetry that satisfies the patient's wishes within the limits of technical feasibility, whilst matching the remaining breast in terms of its contour, dimension and position [2].

Breast volume measurement is of value for augmentation, reduction, oncoplastic and reconstructive procedures of breast including implant size determination [3].

Pre-operative volume assessment is essential for achieving cosmesis in unilateral breast reconstructions, whereby the reconstructed breast should match the opposite breast in shape as well as size. Many of the breast implant companies supply intra-operative sizers of the created pocket for proper selection of the ideal size of the needed implant. It is not possible to have a breast implant sizer for every patient[4].

Although breast volume is particularly important, it is not routinely calculated due to lack of consensus over the accepted standard method. Hence, most surgeons rely upon visual estimation of breast volume, which is not free of error.

An ideal breast volume calculation method should not only be reproducible, reliable and economical, but should also be convenient to the patient. While breast volume calculation by imaging modalities is costly & time consuming, external devices are cumbersome & inconvenient for the patient. Anthropometry has been applied as an objective parameter for surgeries involving repositioning of nipple, correction of ptosis and other breast oncoplastic surgeries. It would hence, be valid to extend the use of anthropometry for breast volume calculation, for its ease of application and as an objective measure of accuracy.

Volume assessment by anthropometric measurements appears simple and economical and formulae proposed by Qiao et al[5] and Oteify et al[4] for breast volume calculation are the only formulae available in literature to assess volume by anthropometric measurements. But their results have not been compared with the volume of post-mastectomy breast specimens.

Hence, it was proposed to study breast volume assessment by anthropometry in breast cancer patients undergoing modified radical mastectomy and compare it with breast specimen volume measured by Archimedes' principle, and establish their correlation, if any, with other parameters.

Material and Methods

This was a prospective clinical study conducted on 50 breast cancer patients undergoing Modified Radical Mastectomy in department of surgery. Informed consent was taken from all patients for enrolment in the study. Patients with fungation or ulceration on breast or stage IV disease, or prior lumpectomy or any other surgery which might alter the shape or symmetry of breast, were excluded from the study.

The breast volumes of these patients were calculated by Oteify et al formula using breast circumference in supine & upright positions, and by Qiao et al formula using breast radii & mammary projection [4,6]. Their respective post-mastectomy specimen volumes derived by Archimedes principle, were taken as controls.

Prior to surgery, brassier size and grade of ptosis were noted in addition to anthropometric measurements. Breast circumference at its base was measured in centimetres with a measuring tape, both in supine and upright positions. Distance from mid-sternal line to nipple was recorded as medial radius; that from anterior axillary line to nipple was recorded as lateral radius and that from inframammary crease to nipple was recorded as inferior radius. Forward projection of nipple, measured in centimetres as distance between the sternum and a vertical flat surface touching the nipple, was taken as mammary projection.

Volume of breast was calculated by following Anthropometric formulae:-

1.Breast circumference based formula by Oteify et al [4]:

• Volume = 0.973 (breast circumference in supine / 6.28)^3

• Volume = 1.193 (breast circumference in upright / 6.28)^3

2. Breast radius & projection based formula by Qiao et al [5]:

• Volume = $\pi/3 \times MP^2 \times (MR + LR + IR - MP)$

Where MP = Mammary Projection, MR = Medial Radius, LR = Lateral Radius and IR = Inferior Radius.

Breast specimen volume was then calculated by the Archimedes principle, after removing the axillary tissue from the MRM specimen, and immersing the remaining breast specimen in a graduated jar filled with water. The volume of water displaced by it was recorded as the specimen volume.

Results of anthropometric formulae were compared with the specimen volumes, and correlated with age, grade of ptosis & bra size. These were then compared with other published & unpublished studies.

Results

In the present study, the breast circumference at its base in supine position ranges from minimum 40 cm to maximum 56 cm with mean value of 51 cm while circumference in upright position ranges from minimum 34 cm to maximum 50 cm with mean value of 43.76 cm. Medial Radius of the Breast ranges with minimum of 8cm to maximum of 19 cm with mean value of 12.6 cm. Similarly Lateral Radius ranges from minimum of 10 cm to maximum of 18 cm with mean value of 13.58 cm and Inferior Radius ranges from minimum of 6 cm to maximum of 12 cm with mean value of 12.5 cm. The Medial & Lateral Radius were almost equal while Inferior Radius was shorter by 40% in all the patients. It was observed that the breast circumference in supine position was always greater than upright position.

The results showed consistent trends in certain parameters such as breast circumference, radii and calculated breast volumes etc. Breast circumference at its base was consistently greater in supine position than in upright position in all cases. While in most cases the medial and lateral radii were almost equal, the inferior radius was about 60% shorter than the two.

Mammary projection is another important aspect of the aesthetic surgery of the breasts. In the present study the mammary projection ranged from 2 to10 cm with a mean value of 5.62 cm and was found to be more in patients who had Ptosis. Mammary projection and distance of nipple from suprasternal notch were also directly proportional to the grade of Ptosis in the present study.

The grade of Ptosis was directly proportional to the distance of nipple from the suprasternal notch. 70% of the patients had Ptosis from grade I to III. The breast circumference, mammary projection, medial, lateral and inferior radii increased with the grade of Ptosis. Similarly, breast volumes calculated by both formulae, as well as breast specimen volumes showed an increasing trend with the grade of Ptosis.

The mean breast volume calculated by the Qiao et al formula, based on breast radii and mammary projection, was the highest. The volume calculated by this formula was more than double the volume calculated by Otiefy et al formula .It was even greater in the age group of 21-30 years. It is a direct consequence of higher mammary projection in younger age than in old age.

Mean volume of the breast specimens was lesser than the volume assessed by the Qiao et al formula, but higher than the volume assessed by the Otiefy et al formula. The mean volume of the breast assessed by circumference in supine was higher than that by circumference in upright position in all cases. The breast specimen volume as well as volume assessed by Otiefy et al formula showed an increasing trend with advancing age. Such a trend was not observed in the volume assessed by Qiao et al formula.

The specimen volumes as well as volumes of the breasts assessed were directly proportional to the assessed bra sizes. While the breast volume assessed by circumference in supine (Otiefy et al formula) matches with the specimen volume for 50% of the patients, that calculated by Qiao et al formula did not match with the specimen volume for any cup size and over-calculated the volume by 50% for all cup sizes.

Breast volumes assessed by both formulae were comparable with the specimen volumes up to the volume of 300 cc. While Qiao et al formula did not remain valid beyond that, Otiefy et al formula remained valid up to 700 cc. Both formulae were found comparable up to the assessed bra size 32

B. On the contrary, for the assessed bra size greater than 36 with cup sizes C or D, none of the formulae gave valid and comparable results.

When the results of this study were compared with other breast volume measurement studies conducted using Magnetic Resonance Imaging (MRI), Mammography, Grossman-Roudner device (GRD), 3-D Biostereometrics method, Casting of breast, Anthropometry and Archimedes method of water displacement, none of them was found superior over other because of variable controls. But when the results of the present study were compared with studies in which specimen volume was taken as control, results were comparable.

Correlation of measurements of Breast with Ptosis

Number of Patients	Grade of Ptosis	Average of Medial + Lateral Radius	Inferior Radius	Mammary Projection	Distance of Nipple from Suprasternal Notch
N=50		Mean in cm	Mean in cm	Mean in cm	Mean in cm
15	Grade 0	11.26	7.26	4.86	18.4
07	Grade I	12.42	8.85	4.85	20.57
17	Grade II	13.11	8.7	5.29	22.88
11	Grade III	15.72	10	7.7	24.45

Correlation of grade of Ptosis with Breast Volume by all the methods

Number of Patients	Grade of Ptosis	Breast Volume by Circumference in Supine	Breast Volume by Circumference in Upright	Breast Volume by Radius & Mammary Projection	Breast Specimen Volume by Archimedes
N=50		cc	cc	cc	cc
15	Grade 0	425	351	703	430
07	Grade I	526	388	779	560
17	Grade II	595	454	952	685
11	Grade III	622	484	2169	809
Total 50					

Discussion

An ideal breast volume method should be reproducible, reliable, economical, harmless and of no inconvenience to patient. Although several methods have claimed to be accurate in breast volume measurement, they have failed to gain widespread acceptance as routine due to high cost, technical difficulties and patient discomfort.

Qiao et al and Oteify et al have proposed their anthropometric formulae for breast volume calculation, based on breast radii & mammary projection, and on breast circumference, respectively[5, 4]. But these formulae have been used in young females whose breasts are non-ptotic and have not been compared with actual breast volume as they were applied in healthy females, who would not undergo mastectomy.

Modified radical mastectomy is still the most commonly performed procedure for carcinoma breast at our institute and therefore specimen volume was available for valid comparison. Hence, the most significant feature of this study was that the results of both anthropometric methods were compared with their respective mastectomy specimen volumes, which served as controls. There are only five studies that have been conducted with specimen volume as the control [3].

Breasts drop down and direction of nipple changes as the age advances. Ptosis of Breasts and the distance from suprasternal notch to the nipple are two most important parameters in the aesthetic surgeries of the Breast. The distance of nipple from suprasternal notch was directly proportional to the grade of Ptosis.

Breast can be presumed as half of a sphere for the purpose of the anthropometric measurements and therefore its volume can be calculated by the formula:

• Volume of Hemisphere = 2/3 π R^3 (R=Radius of hemisphere)

Hence it is important to know the radius of the sphere or hemisphere for calculating its volume. Since radius of the sphere can't be measured directly, it can be calculated from circumference of the sphere because the circumference is equal to 2 π R. Therefore:

• Radius = C / 2 π (C = Circumference of sphere)

or

• Radius = C / 6.28(C = Circumference of sphere)

Thus for assessment of volume of a sphere or hemisphere, either radius should be measured or circumference should be measured. In the breast it is not possible to measure the radius directly and therefore measurement of circumference is the only way to assess its volume. Since breasts are pliable and not exact hemispheres, it is difficult to measure even its circumference which is the limiting factor in anthropometric measurements.

Therefore calculation of volume of the breast requires application of specific formula. Two such formulae have been devised by Otiefy et al & Qiao et al and breast volumes have been calculated on the basis of these formulas in various studies mentioned in the literature which makes the basis of present study.

Otiefy et al measured circumference of the base of breast in a plane parallel to body (horizontal plane) both in supine and upright position for calculation of volume by the formula devised by them in which R is taken as C / 6.28 and R^3 is multiplied by a factor instead of 2 / 3 π (2.093) required for calculation of volume of a hemisphere. This factor is 0.973 when circumference is measured in supine while it is 1.193 when circumference is measured in upright position in their formula:

• Volume = 0.973 (breast circumference in supine / 6.28)^3

• Volume = 1.193 (breast circumference in upright / 6.28)^3

Qiao et al also considered breast a hemisphere but measurements of circumference are done in a plane different than Otiefy et al. Qiao et al used vertical and transverse planes instead of horizontal plane. The measurement of the circumference in vertical plane is done by measuring Inferior Radius while measurement of the circumference in horizontal plane is done by measuring Medial & Lateral Radius. The formula to calculate volume of hemisphere V= π/3 x 2 x R^3 was replaced by their formula:

• Volume = π/3 x MP^2 x (MR+LR+IR – MP)

In this formula MR is medial radius, LR is lateral radius, IR is inferior radius and MP is mammary projection.

It was observed that the breast circumference in supine position was always greater than upright position. The circumference in supine as well as in upright position increases with grade of Ptosis reflecting greater the volume of breast greater will be the Ptosis because of increasing weight of the breast. Average values of Medial & Lateral Radius & Inferior Radius were also directly proportional to the grade of Ptosis. Higher volume assessed by the formula of Qiao et al may also be due to subjective error in measurement of mammary projection because it is measurement between points in two imaginary planes.

Similarly, the volumes assessed by circumference in supine were higher than circumference in upright position. The volumes of breast specimens were lesser than the volumes of breasts assessed by incorporating breast radius and mammary projection while they were higher than the volumes assessed by circumference.

The volume assessments by circumference were in line with the fact that breasts enlarge in size and become heavier as the age advances. With the same method, the volumes in upright position were 20-25% lower than those in supine position, because breast tissue in sitting position falls away from the base, thereby decreasing the circumference at base. Despite this, volume assessments by circumference in upright were

significantly lower as compared to the specimen volumes.

Ptosis of breasts affects all breast measurements including mammary projection and hence, plays a crucial influence on breast volume. Although Ptosis & distance of nipple from suprasternal notch are two most important parameters of aesthetic breast surgery, they have not been incorporated in the methods devised for volume assessment.

Thus it is evident from this study that Ptosis may play an important role in volume calculation by anthropometric methods and therefore requires either to be eliminated when volume of breast is measured by any of such method or it should be incorporated in the method for appropriate calculation of breast volume. In various imaging modalities therefore patients are positioned prone during these imaging studies to eliminate factor of Ptosis such as volume calculation by MRI.

When volume is calculated by Mammography, factor of Ptosis also gets eliminated even in upright position by placing the breasts between the radiolucent plates of the machine. Therefore accuracy of the volume assessments is more with Mammography and MRI in prone position as compare to other methods. Similarly volume of breast has also been calculated by Archimedes principle in which patients are placed prone thereby eliminating the factor of Ptosis.

Various other studies have claimed validity of numerous different methods of breast volume assessment, although none have been accepted as an ideal method. Edsander-Nord in their study concluded that using thermoplastic cast seems to be sufficiently accurate to measure breast volume [6]. Kovacs et al in 2007 calculated breast volume using MRI showed the best agreement with 3D scanning measurement (r=0.990), followed by anthropomorphic measurement (r=0.947) and thermoplastic castings (r=0.727)[7]. Grossman and Roudner found breast volume measurements using GRD were direct and extremely accurate while Kalbhen found most accurate method of calculating breast volume was one that assumed breast as half elliptical cylinder shape on cranio-caudal mammogram [8, 9].

Kalbhen et al [9] used to assess breast volume by mammography in which breast was considered as half ellipse shape on cranio-caudal mammogram and formula used for that was:

Breast volume (V) in ml = $(\pi/4) \times W \times H \times CT$

Where W is width, H is height and CT is compression thickness on mammography machine.

Katariya et al considered breast as a cone and used the formula of calculation of the volume of a cone as shown in figure by following formula [10]:

Breast volume = $1/3\ \pi\ r^2\ h$

Formula of Kalbhen et al was more accurate than Katariya et al in some studies. Fung et al concluded that most accurate and reproducible formula for calculating breast volume was the one that assumed the elliptical cone projection rather than circular cone on mammogram [11]. Bullstrode found calculating the breast volume from mammography that has previously been compared to mastectomy samples shown to be reasonably accurate and therefore method of choice [12]. Kayar has also revealed that the most accurate method was mammography for all volume ranges [3]. We suggest compression thickness to be recorded every time during every mammography so that breast volume can be calculated when desired. This would allow the opportunity to assess breast volume in suitable candidates, since this is the most commonly performed breast imaging in middle aged and elderly women, where anthropometry may not be as accurate in volume assessment.

Conclusion

It is therefore concluded that breast volume can be fairly assessed by both anthropometric formulae in small non-ptotic breasts. For medium sized breasts, the volume assessment can only be assessed correctly by the Otiefy et al formula based on breast circumference in supine. However, volume of very large breasts cannot be calculated accurately by any anthropometric

formula. Although useful and cost effective, a larger study may be required to validate the anthropometric breast volume calculation methods.

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