Body Surface Area as a Surrogate Measure of Gallbladder Sizes and Indices: a Predictive Equation in Humans

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Abstract

Aims: To Find out the relationship between body surface area and gallbladder size; body surface area and gallbladder roundness index; and body surface area and gallbladder spherical index.

Methods: The length, width of 250 normal subjects comprising 140 males and 110 Females were sonographically measured. The gallbladder volumes, roundness index and spherical index were computed for each subject. Pearson's correlation established relationships between body surface area and gallbladder variables. A regression equation of gallbladder volume and body surface area was computed. Tests were two-tailed with $P < 0.05$ indicating statistical significance.

Results: There was a significant linear correlation between gallbladder size and body surface area ($r = 0.400$; $p = 0.007$). The correlation between body surface area and gallbladder roundness index ($r = -0.053$, $p = 0.731$) and body surface area and gallbladder spherical index ($r = -0.133$, $p = 0.389$) were not significant. An equation relating gallbladder volume and body surface area based on a simple linear regression gave GBV (cm3) = 32.036 BSA (m2) – 25.943.

Conclusion: Body surface area significantly correlates with gallbladder size and hence can be used to predict gallbladder sizes prior to cholecystosonography.

Keywords: Body surface area, gallbladder size, cholecystosonography

Introduction

Measurement of gallbladder size is an established diagnostic procedure in the assessment of gallbladder hydrops. Gallbladder spherical index which is a 3-dimensional equivalent of gallbladder roundness index has been suggested as a method for the assessment of gallbladder size. There is an increased fasting gallbladder volume in non-insulin-dependent diabetes mellitus[1]. A positive correlation between fasting gallbladder volume and body weight have been reported[2] Exogenous motilin reduced fasting gallbladder volumes[3] while long term oral L-arginine (L-Arg) increases fasting and postprandial gallbladder volume[4].

Estimation of body surface area (BSA) is most commonly done with a formula that was derived in 1916 by Du Bois and Du Bois but remains the most popular way to estimate body surface area in nomograms or computer programs[5].

An indirect method of predicting gallbladder sizes would be clinically invaluable. This would help in the estimation of gallbladder sizes in patients with suspected cases of hydrops or diabetes induced gallbladder dilatation.

To the best of our knowledge, no prediction formula or regression equation between gallbladder sizes and body surface area has been reported. In this study my aim was to study the relationship between body surface area and gall

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bladder size, roundness and spherical indices in a descriptive environment and establish a predictive equation.

Subjects and methods

A total of 250 apparently healthy volunteers of Ibo tribe ranging from 18 years to 61 years were studied in Ebonyi state, Nigeria between January 2005 and November 2006. 140 were males and 110 Females. Studies were carried out with an abdominal 2 D ultrasound (siemens medical systems, USA Inc, ultrasound Group, Issaquah WA) with a 3.5 MHz sector transducer. Subjects with history of hepatobiliary disease were not included. Diabetic patients were also not included in the study. The study was approved by the local ethical committee of Jeomedics ultrasound centre and informed consent was obtained from each subject.

Each subject was scanned in the morning after an overnight fasting, having previously given an informed consent to participate in the study. Subjects had their weight measured on a bathroom weighing scale: model H 89 LT Blue, and the height measured on a calibrated vertical wall.

Subjects were scanned on supine position. After visualization of the maximal gallbladder longitudinal outline, the length and maximal antero-posterior diameter (height) measurements were taken on arrested respiration with calipers crossing each other at 900. Subsequently the probe was rotated through 900 to obtain the maximal transverse dimension. All measurements were taken thrice and the maximum value recorded. The length, width and height

measurements were taken from the outer to outer hyperechoic walls of the gallbladder (Fig Ia and Ib). Gallbladder volumes were calculated using ellipsoid formula. The gallbladder roundness index (GBRI) (in percentage) was calculated [6]: antero-posterior diameter/length X 100/1. The gallbladder spherical index (GBSI) was calculated[1]:

$$\frac{(\text{Antero-posterior diameter} + \text{width})}{2 \times \text{length}} \times 100/1$$

Body surface area (m^2) was obtained using the formula derived by Du Bois and Du Bois[5];
BSA = (Weight $^{0.425}$ X Height $^{0.725}$) X 0.007184, where weight is in kilograms and height in centimeters.

Values were obtained by one imaging scientist (AC) to avoid possible inter-observer variations. Summary statistics were generated using SPSS 11.0 software while graph was plotted and regression equation was developed in MS excel office 2000. Correlation coefficients (r) and linear regression analysis were performed to assess the relationship between body surface area and gallbladder size. Correlations between BSA and gallbladder indices (GBSI and GBRI) were also calculated. Tests were two-tailed with P < 0.05 indicating statistical significance.

Result

The result of the statistical analysis of the data on body surface area and gallbladder parameters are shown in Table 1.
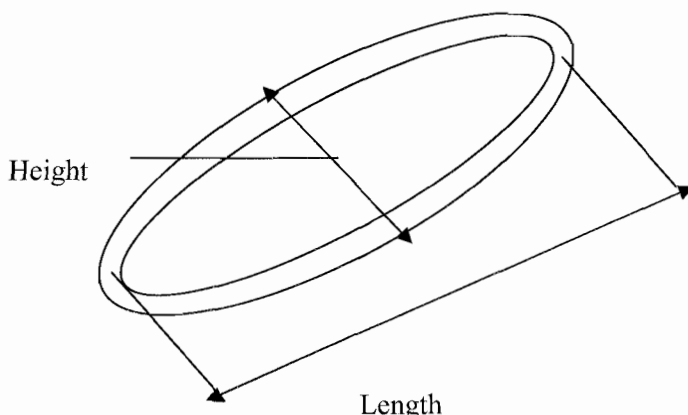

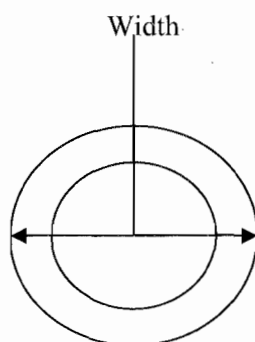Fig 1a : A line drawing showing a longitudinal section of the gallbladder.

Fig 1b: A line drawing showing a transverse section of the gallbladder.

Table 1. Descriptive statistics of subjects

Variable	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
BSA	250	1.35	2.17	1.7573	0.17301	-0.123	0.450
GBV	250	7.78	71.21	29.2893	13.75489	1.320	1.777
GBRI	250	22.54	55.38	42.2382	8.34084	-0.190	-0.745
GBSI	250	26.76	57.69	42.2509	8.37422	0.167	-1.070

There was a significant linear correlation between body surface area and gallbladder sizes (r = 0.4, P = 0.007). The BSA did not correlate significantly with GBRI and GBSI. The Pearson's correlation coefficient between BSA and GBSI was r = -0.133, P = 0.389 while the correlation between BSA and GBRI was r = -0.053, P = 0.731.

Fig 2 is a graph of gallbladder size (cm3) against BSA (m2). A regression equation of gallbladder volume on BSA gives: GBV = 32.036 BSA –26.943.
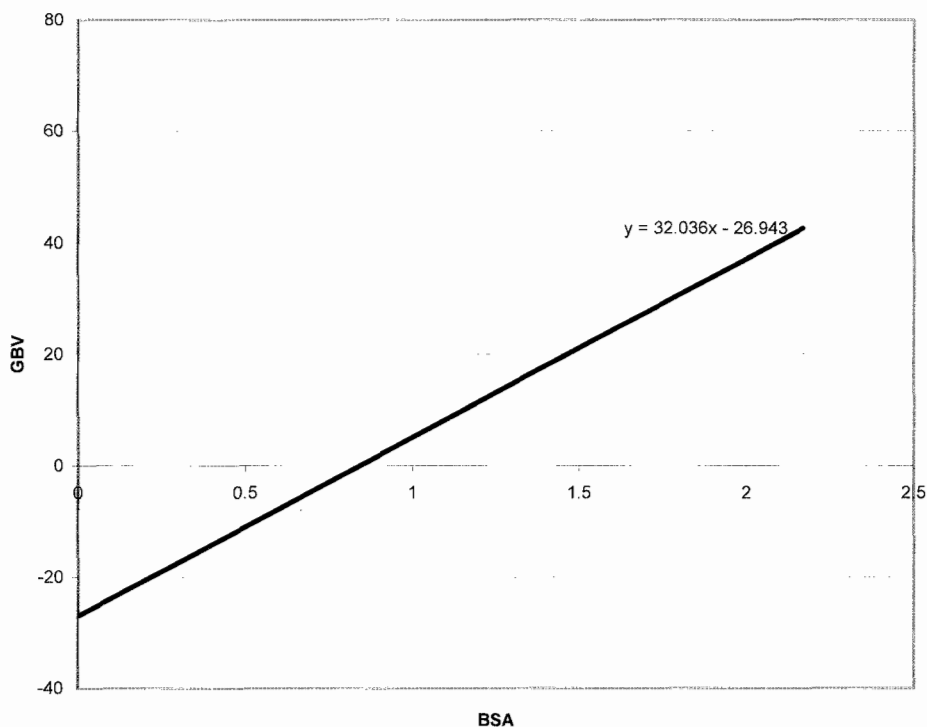

Fig 2: A graph of Gall Bladder Volume (cm3) against Body Surface Area (m2)

Discussion

Oral cholecystography, which depends on adequate absorption of the oral contrast medium from the small intestine, its excretion from the liver with bile, the patency of the cystic duct and finally adequate concentration by the gallbladder, was the first popular technique for the assessment of gallbladder sizes and structural changes. With the increasing use of high-resolution sonography in the gallbladder, sonography has become the commonest imaging modality in evaluating gallbladder sizes.

Gallbladder contours differ much in humans. In the assessment of gallbladder function, a study[7] has shown that the estimation of gallbladder volume based on one direct measurement of length exhibits satisfactory precision to be applied in all the situations where the assessment of gallbladder function should be more rapid and simple. The accuracy of this method can be even greater than that of the widely accepted and applied ellipsoid method[8, 9] since the former method is based only upon one gallbladder

parameter. When the new method is applied, it is recommended to select the proper formula depending on gallbladder shape[7].

When the shape resembles the ellipsoid or the sphere, the ellipsoid method is recommended. When the gallbladder is thinner, the use of method of cone[10] is suggested. When the gallbladder is rather thick and exhibits atypical shape, the method of cylinder[11] can provide more accurate results.

In this study, a significant positive correlation was established between BSA and gallbladder volume, while correlations between BSA and gallbladder indices (GBSI and GBSI) were noted to be insignificant. This result is similar to a previous study[2], which established a positive correlation between gallbladder volume and body weight, body mass index and body fat weight. The significant finding in this study agrees with a previous study[12] which established a moderate and significant correlation between body surface area and gallbladder volume(r=0.57; p<0.01).

To the best of our knowledge, this is the first time a prediction equation for gallbladder volume was established.

An obvious limitation in this study was the use of ellipsoid method for the evaluation of all the assessed gallbladder (shapes). Future studies adopting the supposed formula for different gallbladder shapes are advised. Three dimensional ultrasonography is fast becoming highly utilized in the ultrasound laboratory and may well prove to be the appropriate technology in future studies[13] .In this study, all the measurements were taken by one imaging scientist (AC). This was done to avoid possible interobserver errors, as it has not been previously investigated. Future studies on intra- and inter-observer variation in the 2 dimensional assessment of gallbladder dimensions and volumes are recommended. Despite these obvious limitations, this study has shown that body surface area significantly correlates with gallbladder volume and hence can be used to predict gallbladder sizes ($\pm$ 2 standard deviation) prior to cholecystosonography.

Acknowledgement

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