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Journal of Clinical Images

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# Ultrasonic Mean Cut off Values of the Expiratory Inferior Vena Cava (IVC) Diameter in Some Body Adipocities

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Received: Dec 13, 2021

Accepted: Jan 20, 2022

Published Online: Jan 24, 2022

Journal: Journal of Clinical Images

Publisher: MedDocs Publishers LLC

Online edition: http://meddocsonline.org/



**Keywords:** Ultrasonic; IVC diameter; Body adiposities; Cutoff values.

## Abstract

**Background:** Dilatation of the Inferior Vena Cava (IVC) is used as the ultrasonic diagnostic feature in patients suspected of congestive heart failure. The IVC diameter has being reported to vary among the various Body Surface Area (BSA) Knowledge of these variations is useful in precision diagnoses of CHF by imaging scientists.

**Aim:** The study aimed to determining the ultrasonic mean expiratory diameter of the IVC among the various BMI and ABSI of inhabitants of Azare, Bauchi State-Nigeria.

**Methods:** Two hundred physically healthy adult subjects of both sexes were classified into under; normal, over and obese weights using their BMIs and ABSIs after random selection using a structured questionnaire to rule out those that were affected by the exclusion criteria. Their informed consent was sought for abdominal ultrasound scan. The probe was placed on the mid line of the body, half-way between the xiphoid process and the umbilicus with the marker on the probe directed towards the patient`s head to obtain a longitudinal view of the IVC. The maximum IVC diameter was measured from the subcostal view using the electronic caliper of the scan machine during expiration on a B mode. The mean value of each group was obtained and analyzed statistically.

**Results:** It was observed that, the mean expiratory diameter of the IVC in underweight normal weight, overweight and obese individuals along with their corresponding ABSI by BMI were 1.1480 ± 0.03, 1.346 ± 0.028, 1.3062 ± 0.087 and 1.4475 ± 0.089 (cm) respectively, with the underweights significantly decreased compared with the normal and obese weights (P value ≤ 0.05).

**Conclusion:** In conclusion, the normal cutoff values for indicating a dilated IVC among the populace has been established.

**Cite this article:** MK Yusuf, WO Hamman, UE Umana, SB Oladele. Ultrasonic Mean Cut off Values of the Expiratory Inferior Vena Cava (IVC) Diameter in Some Body Adipocities. J Clin Images. 2022; 5(1): 1110.

## Introduction

The anthropometrics commonly used in health care include Body Mass Index (BMI) and Waist Circumference (WC) which is an indicator of the degree of obesity estimated with height and weight and it is known to be correlated with the risk of premature death as well as diseases such as CCF [1].

However, both BMI and WC have their limitations in medical practices [2]. In some Asian population, a study conducted among normal subjects in Karachi, the largest city in Pakistan, reveals that body mass index is reliable parameters to be considered for avoiding false positive diagnosis of hepatomegaly, heart failure and portal hypertension on a sonogram [3]. Nutritional status and Body Surface Area (BSA) have been reported to affect the dimension of the IVC and the intrahepatic vascular channels [3]. BMI and WC have their limitations in medical practices [2].To address this limitation, a new metrics was developed known as A Body Shape Index (ABSI)

Congestive cardiac failure is a global pandemic with an estimated twenty six million (26 Million) people reported to be affected world- wide [4]. CCF is a pathological condition occasioned by volume overload of the heart mainly due to ischemic and non ischemic factors leading to poor venous return and consequently, dilatation of the IVC [4].

Dilatation of the Inferior Vena Cava (IVC) is used as the ultrasonic diagnostic feature in patients suspected of congestive heart failure [5]. The IVC diameter has being reported to vary among some body anthropometry [3]. However, no known study of this nature has been carried out on the Body Mass Index (BMI). Knowledge of these variations is useful in precision diagnoses of CHF by imaging scientists. A dilated Inferior Venae Cava (IVC) whose luminal diameter is unstable due to pattern of breathing, intra thoracic pressure variations and the extent of diaphragmatic excursion among individuals is also a prominent landmark in CCF diagnoses [6].

Ultrasound scanning machine is useful in the evaluation of porto-systemic diseases like congestive cardiac failure [7]. In ultrasound examination, the anatomical structure of focus in diagnosing patients queried of heart failure is the inferior vena cava [5]. The use of ultrasound to accurately diagnose some critical pathological condition, such as porto systemic diseases like congestive cardiac failure often puzzles sonographers especially amateurs in the field and as such, they require great care, confidence among other factors in the use and manipulation of equipment apart from having a thorough knowledge and understanding of the anatomy of the inferior vena cava and and it`s pathophysiology in other to make reasonably accurate diagnoses of congestive cardiac failure [8]. This study therefore, investigates the potential use of BMI to establish cut off values for the ultrasonic expiratory IVC diameter among the various BMI types in the healthy subjects of the inhabitants of Azare, Bauchi State, Nigeria and to also serve as a potential indicator of CCF among the subjects.

## Materials and methods

The materials used for the study include the following:

Sono-crown ultrasound machine, 3.5MHZ of linear probe (transducer), gel, sono-printer, weighing scale, tape rule and a stadiometer and questionnaires

### Experimental design

Subjects were classified in accordance with their BMI types based on W.H.O indices in the African population where an individual with a BMI less than or equal to 18.49 is considered as underweight, 18.50- 24.99; normal 25.0-29.99 are considered as overweight and 30.0 or more are considered as obese. As shown in the Table 1. The Expiratory Diameter of the Inferior Vena Cava (MEDIVC) in underweights, normal, over weights and obese were measured and the mean obtained.

**Table 1:** Experimental Design of Variables in Healthy Subjects.

| Groups | BMI | ABSI | MIVCED |
|---|---|---|---|
| 1 | Underweight | | |
| 2 | Normal weight | | |
| 3 | Over weight | | |
| 4 | Obese | | |

### Sample Size

A cross sectional survey was done using systemic random sampling technique whereby the sample size of the research was determined using Yamane equation (indicated below: $ny = \frac{N}{(1+Ne^2)}$ [9]. Where ny is sample size, N is Population size; e is alpha level = 0.05 (If confidence interval is 95% or 0.95).

According to the National Population commission (2020), the population of Azare, Bauchi was estimated at 411,700. From the above formula, the sample size was calculated and the value of three hundred and ninety nine (399) was obtained.

### Study location


**Figure 1:** Insert in the Nigerian map is the geographical site of Azare, Bauchi, State.

Azare is locatedin katagum, Bauchi, Nigeria. It`s geographical coordinates are 110 40` 42`` North, 100 11` 31`` East (Maplandia.com) (Figure 1).

### Sonographer/Ultrasound unit

The ultrasound unit of Shifa`a Medical Centre, General Hospital and Federal Medical Centre all of Azare, Bauchi State were used for the study and the measurements were taken alongside with a certified and competent sonographer or a radiologist between April to December, 2020

**Inclusion criteria**

- All persons between the ages of 18 and 77 years and apparently healthy
- All persons without CCF (normal or healthy subjects)

**Exclusion criteria**

- All persons below the age of 18 years and above 77 years
- All persons with known hepatobilliary diseases like splenomegally, history of cholecystectomy or cardiac Operation.
- All persons diagnosed of CCF that are either on treatment or not.
- All pregnant women.
- All persons with obvious anatomical defect

## Patient and methods

A randomly selective prospective study was carried out at Shifa`a Medical Centre, General Hospital and Federal Medical Centre all in Azare, Bauchi State between March to December, 2020. Two hundred (200) non CCF subjects comprising males and females subjects, aged between eighteen and seventy seven were randomly selected and grouped into four with a membership of twenty five each to represent their BMI/ nutritional status. That is under weight, normal, over weight and obese weight. A structured questionnaire was used to help rule out those that fell within the inclusion criteria. They were subjected to abdomino-pelvic ultrasonography for assessment of the Inferior Venae Cava (IVC) diameter in both inspirational and expiratory phases.

**Experimental procedures**

Each subject was placed in a supine position and was encouraged to fast overnight in order to decrease the amount of bowel gas which may obscure the target structures. Male subjects were requested to put off their tops while female subjects were required to raise their tops, up to the sub coastal margin. The abdomen preset was clicked on the ultrasound machine which is the recommended interphase for examining abdominal structures. A low frequency probe (3.5 MHZ), that is, curvilinear transducer was used with an ultrasound gel applied on it.

**Positioning and probe selection**

The probe was placed on the mid line of the body, half-way between the xiphoid process and the umbilicus with the marker on the probe directed towards the patient`s right side to obtain a transverse view. At this level, the IVC and the abdominal aorta was seen as elliptical and circular anechoic structures anterior to the vertebral body respectively. The gain on the machine was adjusted to get the best possible image. The IVC appears as an elliptical or "tear drop" structure on the right side of the patients mid line while the aorta appears on the left side. The IVC appears compressible under gentle pressure and not as pulsatile as the aorta. The IVC shows a change in diameter during inspiration and on sneezing while the aorta remains adamant to these factors. The probe was rotated longitudinally in clockwise direction to ninety degrees with the marker on the probe directed towards the head of the patient to obtain the longitudinal axis of the IVC. The long axis of the IVC was seen clearly below the xiphoid process with a branch of the hepatic vein draining into it. As shown below (Figure 2).

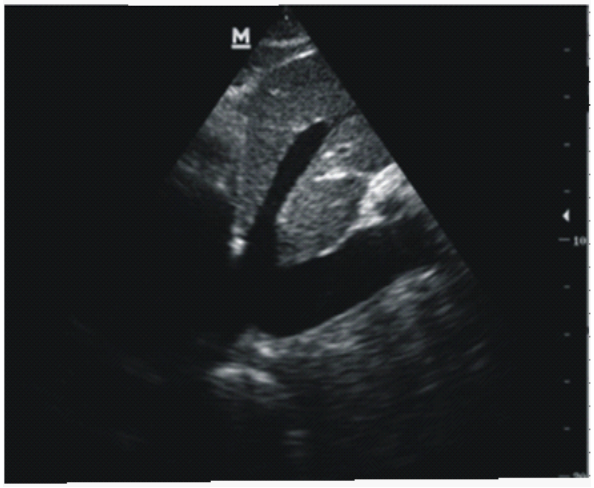
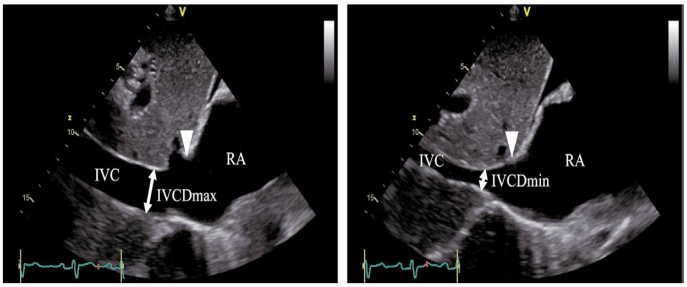


**Figure 2:** Distended IVC in long axis view [10].

The maximum IVC diameter was measured from the subcostal view with the IVC displayed along its long axis in accordance with the method of Kawata et al., [10]. The diameter was measured immediately caudal to the junction of the hepatic vein with the IVC and approximately 1-2 cm caudal to the junction of the IVC and the ostium of the right atrium as shown in (Figure 3a, 3b and 4).




End-expiratory period After brief sniff

**Figure 3 A&B:** Example of IVC ultrasound in the subcostal long axis view: Arrowhead indicates the IVC-RA junction. IVC: Inferior Vena Cava; RA: right atrium [10].

**Figure 4:** Image of the inferior Vena Cava (Transverse veiw) obtained from a 54 yr. Old male subject for IV C diameter measurement. Arrow indicates anterior - posterior (AP) direction.

**Measurement of body mass index**

The height and weight of each subject were measured and the BMI/ABSI were determined using Quetelets' formula, that is; $ny = \frac{N}{(1+Ne^2)}$ [11,12].

**Height**

Height was determined using a height stadiometre. The subject or individual was asked to stand straight against a stadiometre; touching the stand with heels, buttocks and back. The head was oriented in Frankfurt plane (the upper body of the ear opening, the lower body of the eye socket on a horizontal line) and the heels are brought together. The subject was asked to stretch upward and to take and hold a full breath, the headboard of the stadiometer was lowered until it firmly touched the vertex of the head and the height was taken as described by Ayo et al., [13] and Mike et al.,[14].

**Weight**

The subjects were dispossessed all weighty items on their cloths and asked to mount on the Centre of weighing scale. The record of the weight was taken to the nearest tenth of a kilogram as described by Mike et al., [14].

**A body shape index**

The body shape index of the subjects were calculated using the formula below with the aid of Microsoft excel and in accordance with the methods of Krauker.

$$ABSI = \frac{WC}{BMI^{\frac{2}{3}} \times Height^{\frac{1}{2}}}$$

**Blood pressure (BP) measurements**

The subject's blood pressures were obtained in accordance with W.H.O guidelines 2021 [15]. Those with blood pressure ranging between 110/90 -120/80 (mm HG) were considered as healthy subjects.

**Statistical analysis**

Data obtained were expressed as mean +/- (SEM) standard error of mean, one way Analysis Of Variance (ANOVA) was used to compare the mean difference between and within the groups and the level of significance was set at $p \leq 0.05$ and a 95% confidence interval was applied to the numerical variables which are normally distributed. Statistical analysis was carried out using Statistical Package for Social Science (SPSS) Version 20.

## Results

The mean values of the ultrasonic inferior vena cava expiratory diameter among the various body mass index (s) and their corresponding Body Shape Index (ABSI) by BMI were determined using ANOVA The results from show that, the mean ultrasonic expiratory diameter of the Inferior Vena Cava (IVC) in underweight, normal weight, overweight and obese individuals along with their corresponding ABSI by BMI were 1.1480 cm, 1.346 cm, 1.3062 cm and 1.4475 cm, respectively (P value ≤ 0.05).

The level of significant differences in the mean expiratory diameter of the ultrasonic Inferior Vena Cava (IVC) of the various body mass indices and it`s corresponding Body Shape Indexes (by BMI) between the groups that is, with each other and multiple comparison were determined using ANOVA. show that the mean expiratory diameter of the ultrasonic Inferior Vena Cava (IVC) of an underweight individual (1.1480) with it`s corresponding Body Shape Index (ABSI) is significantly decreased compared to that of the normal (1.346) and obese (1.4475) healthy individuals ƒ (3.197) = 5.592, P-value < 0.001, §$p^2$ (Eta square value) = 0.08. However, no significant difference (P < 0.05) was observed in like manner between an underweight and an overweight individual. No significant difference (P < 0.05) was also observed in the IVC diameter of overweight individuals and other Body Mass Indices /A Body Shape Indices (ABSI) types (Figure 5).

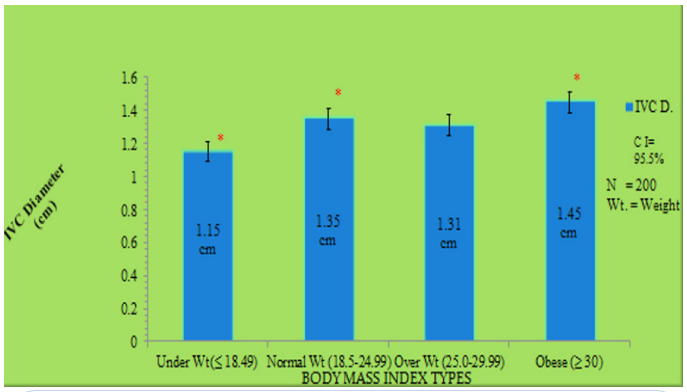



**Figure 5:** Bar Chart of Body Mass Index Types versus Inferior Vena Cava diameter.
CI: Class Interval; *: Significant difference.

## Discussion

Observations made from this study indicated that, the ultrasonic mean expiratory diameter of the Inferior Vena Cava (IVC) in underweights, normal weights, over weights and obese healthy subjects along with their corresponding ABSI by BMI differs among each other .The observed differences in the IVC diameter was reflected in the variation of BMI/ABSI values obtained from the study. These findings are in congruence with the work of Taniguchi et al., [3] who reported that body size may be an important consideration when Inferior Vena Cava Diameter (IVCD) is used for assessing Right Atrial Pressure (RAP). It further indicated that Sunyer et al., [16] had earlier reported that body fat is accompanied by profound changes in the physiological and metabolic functions (homoeostasis) of the body, which are directly dependent on the degree of excess weight and on its distribution around the body. Since BMI is a function of fat deposition though a sub optimal marker of total body fat percentage, it probably advanced the reasons for the observed variations in the mean IVC diameter among the various BMIs/ABSIs in this study. These findings therefore, indicated that, the body mass index of an individual influences her ultrasonic IVC diameter.

## Conclusions

It can be concluded from this study that, The ultrasonic mean expiratory diameter of the Inferior Vena Cava (IVC) in underweights, normal weights, over weights and obese healthy subjects along with their corresponding ABSI by BMI have been established.

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