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Ultrasonographic Determination of Normal Splenic Size of Adult Population at Tibebe Ghion Specialized Hospital, Bahir Dar, North West Ethiopia

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**BAHIR DAR UNIVERSITY COLLEGE OF MEDICINE AND
HEALTH SCIENCES, SCHOOL OF MEDICINE, DEPARTMENT
OF CLINICAL RADIOLOGY**

**ULTRASONOGRAPHIC DETERMINATION OF NORMAL
SPLENIC SIZE OF ADULT POPULATION AT TIBEBE GHION
SPECIALIZED HOSPITAL, BAHIR DAR, NORTH WEST
ETHIOPIA**

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**A RESEARCH THESIS TO BE SUBMITTED TO DEPARTMENT OF
CLINICAL RADIOLOGY, SCHOOL OF MEDICINE, COLLEGE OF
MEDICINE AND HEALTH SCIENCES, BAHIR DAR UNIVERSITY IN
PARTIAL FULFILLMENT OF THE REQUIREMENT IN SPECIALTY
CERTIFICATE IN CLINICAL RADIOLOGY.**

FEBRUARY, 2022

BAHIR DAR, ETHIOPIA

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BAHIR DAR, ETHIOPIA

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ABSTRACT

Background: Spleen is the largest lymphoid solid organ containing reticuloendothelial system and located intraperitoneally in the left upper quadrant of the abdomen. Knowledge of the normal range of spleen size in the population being examined is a prerequisite. Established normal limits of spleen dimensions remain few in the Ethiopian population, and the ultrasound data from the previous studies of different countries demonstrated that racial and geographic differences could affect the splenic dimensions; this necessitates the determination of normative data of spleen dimensions for our population. Ultrasonography is the best imaging method to assess the spleen and splenic size.

Objective: The aim of this study was to determine normal spleen sizes by ultrasonography in adult population at Tibebe Ghion Specialized Hospital, Bahir Dar, North West Ethiopia, 2021.

Methods: Institutional based cross-sectional study was conducted on adult population at Tibebe Ghion Specialized Hospital to determine a normal size of spleen by ultrasonography during the study period. The respondents were selected by simple random sampling and the data were collected through structured questionnaires, checklists and sonographic dimensional measurements by senior radiology residents. Then, data were checked for completeness, cleaned, entered and analyzed using SPSS version 23 and presented with descriptive and analytical statistics. Relationship between spleen sizes and each of the variables were assessed with Pearson's correlation coefficient with R value > 0.2 and P value < 0.05 .

Result: A total of 402 adult participants consisting of 185(46%) male and 217(54%) female were enrolled in the study. The age range of the participants was between 18 and 80 years with mean age of 37.67years (± 14.9). The mean weight, height and BMI of the participants were 162.5 cm (± 8.12), 54.91kg (± 9.64) and 20.76 (± 3.28), respectively. The mean and range of splenic length, width, thickness and volume of all participants were 10.35cm (± 1.16) & 7.1-12.8cm, 3.7cm (± 0.38) & 2.5-4.7cm, 6.72cm (± 0.44) & 5-8cm and 136.7cm³ (± 35.29) & 49-244cm³, respectively. Males had larger spleen dimensions than female participants. All the spleen dimensions had statically significant moderate positive correlation with weight, height and BMI of the participants at value of $r > 0.2$ and $P < 0.001$ and age had significant negative effect on spleen dimensions.

Conclusion: The normal spleen size is influenced by age, sex and body habitus, with younger, men, and taller or heavier individuals having longer and larger spleens.

Key words: adult, spleen, size, dimensions, ultrasonography

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ABBREVIATION

AP	Anteroposterior
BDU	Bahir Dar University
BPH	Benign Prostatic Hypertrophy
CM	Centimeter
CT	Computed Tomography
LAP	Lymphadenopathy
L	Spleen Length
MRI	Magnetic Resonance Imaging
MRN	Medical Record Number
MM	Millimeter
P	p-value
R	Pearson correlation coefficient
SPSS	Statistical Package for the Social Sciences
TGSH	Tibebe Ghion Specialized Hospital
T	Spleen Thickness
US	Ultrasound
W	Spleen Width

CHAPTER ONE

1. INTRODUCTION

1.1 Back ground

Spleen is the largest reticuloendothelial solid organ located intraperitoneally in the left upper quadrant of the abdomen sandwiched between stomach fundus and diaphragm, with its long axis in the line of the left 10th rib. The normal adult spleen has two surfaces; smooth convex superolaterally (diaphragmatic) and nodular concave inferomedially (visceral) surface. The diaphragmatic surface is convex and is usually situated between the 9th and 11th ribs. The visceral or inferomedial surface has gentle indentations where it comes into contact with the stomach, left kidney, pancreas, and splenic flexure of the colon. The spleen is suspended (maintained in place) by the splenorenal ligament, which is in contact with the posterior peritoneal wall, the phrenicocolic ligament, and the gastrosplenic ligament. The splenic hilum is located on the anteromedial surface containing the major splenic vessels, lymphatic channels and pancreatic tail within splenorenal ligament. Splenic artery and vein run superior and posterior to pancreas, respectively, through the splenorenal ligament at the tip of the pancreatic tail (1-5).

Knowledge of spleen size is important in the evaluation of gastrointestinal and hematological diseases for both radiologists and clinicians(6). Multiple studies in different countries and areas have tried to establish nomograms of spleen size for different population. They determined average spleen length less than 12cm, thickness less than 7cm and the width less than 5cm. They also tried to establish the correlation between spleen size and associated factors (age, sex, height, weight, races), with men, taller and heavier individuals have larger spleen size than their counterpart(7-10). However, the established normal limits of spleen dimensions remain scanty in the Ethiopian population, and the ultrasound data from the previous studies of different countries demonstrated that racial differences which could affect the splenic dimensions; this necessitates the determination of normative data of spleen dimensions for different areas, like our country, Ethiopia (11).

Spleen has a lot of functions include phagocytosis, fetal hematopoiesis, adult lymphopoiesis, immune response, and erythrocyte storage or sequestration (1, 2). Variety of the disorders causes

malfunctioning of one or combination of the splenic functions, these disorders include portal hypertension, glycogen storage disease, leukemia, lymphoma, melanoma, malaria, infectious diseases, schistosomiasis and other hematologic diseases causes abnormal spleen size, mostly splenomegaly (12-14). For the evaluation of these splenic disorders the baseline normal spleen size (normal limit) is necessary, which is not known for our country, Ethiopia, particularly in our society.

So far, various clinical and imaging techniques are being used in the evaluation of splenic size or volume in different countries on different population, this includes clinical palpation and imaging modalities such as conventional radiography, ultrasonography, scintigraphy, computed tomography, and magnetic resonance imaging (2, 15). But some of these measurement techniques have associated limitations. Clinical palpation results over or underestimation of the actual spleen size. May be difficult to identify mild splenomegaly on clinical examination as it is covered by lower ribs and to be clinically palpable the spleen size has to be enlarged 2 to 3 times its normal size (8, 16).

Additionally, abdominal radiographs have limited role in the evaluation of the spleen. Although, CT and MRI are more accurate in volumetric measurements of the spleen, they hampered from routine use for the diagnosis and serial follow-up of patients for suspected splenic enlargement because of the associated high radiation exposure (CT), especially in a pediatric, adolescent or pregnant population, limited availability and the expensive cost in our environment (1, 15, 17, 18). Scintigraphic examination of the spleen by using Sulphur colloid is also used for spleen size measurement but mainly helpful in localizing ectopic splenic tissue and associated with radiation exposure (6, 19).

Recently, ultrasonography is the most widely used imaging modalities in estimation of accurate spleen size because it is very simple, safe and helpful for closely follow up of the patients with persistent splenomegaly for development of complications. Besides these, ultrasound scanning is non-ionizing, non-invasive, widely available, reliable, easy to use and less expensive than other imaging methods. However, its main limitation is being operator dependent which can be improved on experienced hand (2, 14, 15).

Generally, the normal sonographic appearance of the splenic parenchyma is homogeneous, comma-shaped or crescent shaped with an echogenicity similar or slightly hyperechoic to the

liver renal parenchyma. Splenic vein is a very useful landmark in identifying the spleen and splenic hilum during ultrasound scan, which is generally can be demonstrated without difficulty (1, 4, 10, 20).

1.2 Statement of the problem

Since spleen is the largest reticuloendothelial and intrabdominal organ, like other intraabdominal organs, it may be affected by variety of disorders, including infectious, infiltrative, hematologic, congestive, and malignant conditions. Majority of these disorders cause spleen size changes; mainly splenomegaly (1, 13, 14). The small spleen or splenic atrophy is also another common problem seen in diseases like sickle cell anemia and celiac disease. The progressive atrophy as a result of repeated attacks of Vaso-occlusion and infarction caused by these diseases leads to auto splenectomy (21-24). Assessment of the splenic size is essential in the diagnosis of small, normal or enlarged spleen.

Spleen size varies with different factors including age, sex, weight, height, BMI, nutritional factors, body habitus, geographical location, physical activities, race, and ethnicity of the individuals. Therefore, these factors make difficulty in assessment of splenomegaly and small increases in spleen size. This necessitates the assessment of the correlation between the spleen sizes and associated factors during its interpretation (11, 13, 25-29).

In Ethiopia, yet, there is limited standard baseline dimensions for normal spleen sizes. We are using the foreigner textbooks as a baseline reference for spleen dimensions, in which the subjects of study were different from our society regarding to body habitus and races (3, 8, 28). Thus, it directs us to have our own baseline spleen dimensions for our society particularly in our hospital.

Additionally, Ethiopia is an endemic for many diseases including malaria (13.6%), tuberculosis, schistosomiasis, leishmaniasis, viral hepatitis, and other noncommunicable diseases (portal hypertension, lymphoma and hematologic diseases) that result directly or indirectly splenomegaly, which guide us to determine a baseline sonographic spleen normogram with which reference can be made (30-33). This is the rationale for this study.

Therefore, the purpose of this study was to determine reference guidelines for normal splenic sizes in our adult population by using sonographic method and to compare our final findings to other populations' data.

1.3 Significance of the study

The spleen sizes were assessed and documented for adult population of North West Ethiopia (Bahir Dar and its surrounding area) and thereby serve as a baseline for comparison in cases of splenomegaly using ultrasonography.

This study found the correlation between the spleen dimensions and associated factors (body parameters). Means it will remind the physicians, radiologists and radiology technologists, to consider these factors to avoid misinterpretation of the spleen dimensions.

Bahir Dar university, TGSB may help in preparing guideline for normal spleen dimensions for Bahir Dar city and its surroundings using the results of this study.

Finally, the findings of this study will serve as a reference for researchers.

2. LITERATURE REVIEW

American text book stated, spleen size measurement is helpful to have measurements that establish the upper limits of normal size, as measurement in other body structures. The size of a normal spleen depends on gender, age, and body-height. The combination of complex irregular shape and the range of the normal sized adult spleen, makes it difficult to establish a normal range of sonographic measurements. Therefore, the assessment splenic volume or weight is preferable (1).

Another USA requisite book series revealed the ultrasound (US) measurements of the mean length of spleen is typically 11 to 12 cm in long axis. Its transverse dimension is rarely measured but is typically 7 to 8cm in thickness and 4 to 5cm in width. Splenomegaly is classified as >14 cm in length (longitudinal axis) (10).

Research done on collegiate athletes in USA, revealed that the mean splenic length and width was 10.65 and 5.16 cm, respectively. Men had larger spleens than women. White subjects had larger spleens than African-American subjects. Also, it stated that previous history of infectious mononucleosis or the presence of recent cold symptoms had no significant effect on spleen size (8).

The study conducted in Canada on tall healthy athletes, indicates the average length of spleen was found to be 11.4 cm in males and 10.3 cm in females. Average width of spleen measured was 5.0 cm in males and 4.2 cm in females. All these dimensions of spleen were best correlates with height of the patients. In women taller than 168 cm, the mean splenic length of 10 cm increased by 1 mm for each 1-inch incremental increase in height. In men taller than 180 cm, the mean splenic length of 11 cm increased by 2 mm for each 1-inch incremental increase in height. Upper limits of normal in splenic length were 14 cm in women 198 cm tall and 16.3 cm in men 213 cm tall. This study also revealed poor correlation between spleen length and left renal length (27).

A cohort study done in Germany on 1230 adult individuals (324 women and 906 men), with a mean BMI of 25.0 kg/m², age of 31years and age range of 18-55yrs, showed that the median spleen length, width, thickness and volume 10.9cm (range:8.7–13.3 cm), 4.5 cm (range: 3.2–6.7

cm), 6.5cm (range: 4.1–8.9 cm), and 166 cm³ (range 80–324 cm³), respectively. And the spleen length and volume were significantly and independently associated with sex, body height and weight, with men and taller and heavier individuals having longer and larger spleens. The spleen length of 6% of women and 26% of men exceeded the previously reported upper limit of normal of 12 cm (26).

The study conducted on 93 subjects in Russia, demonstrated the average age, weight and height of the participants, which was 23.1 ± 2.77 years (range from 18 to 31 years); 62.4 ± 12.3 kg and 168 ± 9.2 cm, respectively. This study also revealed the average spleen length, width, thickness and volume, which were 10.1 ± 1.5 cm, 4.2 ± 0.83 cm, 6.1 ± 1.8 cm, 141.15 ± 72.4 cm³, respectively and intersplenic dimensions correlation(34).

A study conducted in India on 205 subject's correlates spleen dimensions with sex, indicating that the total mean splenic length, width and thickness were 9.2 cm, 3.7 cm, and 8.2 cm respectively. The mean splenic length, width and thickness for females were 8.8 cm, 3.6 cm and 7.9 cm respectively, while mean sizes for males were 9.6 cm, 3.99 cm and 8.5 cm, respectively. Females had smaller spleen size than males subjects (2).

Another study done on 166 subjects, in Kosi region of India, shows the splenic length and thickness decreases at a slow rate up to the age of 50 years after which it decreases rapidly in both sexes. Mean splenic length in the first age group (21-30 years) was 10.2 cm, 9.42 cm, in the second age group (31-40 years) was 9.98 cm, 9.32 cm, in the third age group (41–50 years) was 9.16 cm, 8.73 cm and in the fourth age group (51- 60 years) was observed to be 8.46 cm, 8.34 cm for male and female respectively. Mean splenic thickness in the first age group was 6.09 cm, 5.39 cm, in the second age group was 5.64 cm, 4.6 cm, in the third age group was 4.66 cm, 4.49 cm, and in the fourth age group was observed to be 4.46 cm, 4.3 cm, for male and female respectively. The splenic length, width and thickness are greater in males than in female in each age group (15).

The spleen measurements of Turkish adults were found to be thickness -7.58 cm, length-9.87 cm, width-3.34 cm and volume-136.05 cm³ in female and thickness-8.75 cm, length-11.01 cm, width-4.12 cm and volume -220.70 cm³ in male subjects. It also found that all dimensions were greater in males than females and splenic length decreased with increase in age in both genders (13).

A study conducted in Jordan revealed that, the mean splenic dimensions were 10.72 cm in length, 7.4 cm in thickness, 4.4 cm in width, and 184.15 cm³ in volume. Men (L= 11.09 cm, T= 7.28 cm, W= 4.93 cm, V= 206.39 cm³) had larger spleens than women (L=10.25 cm, T= 7.55 cm, W= 3.73 cm V=155.72 cm³). There was a significant moderate positive correlation between the spleen volume and other parameters (height, weight, and BMI), but the age had no significant effect on volume (25).

A study done on African population revealed that the mean spleen length was 8.9 cm, width of 4.9 cm, thickness of 5 cm and spleen volume 119.5 cm³. The mean spleen size of Africans was smaller than western population and the men spleen size was larger than women. However, correlation of splenic size with age, weight or BMI was not reported (12).

Research conducted in North Western Nigeria, shows the mean splenic length, width and thickness for the subjects were 10.2 cm, 4.7 cm, and 8.7 cm, respectively. The mean splenic length, width and depth for females were 9.8 cm, 4.6 cm and 8.4 cm, respectively while that for males were 10.4 cm, 4.8 cm and 8.8 cm, respectively, indicating that the mean splenic sizes for females is lower than that of males. Positive correlation was found between subjects height and weight with splenic length, depth and width, but showed poor correlation between subjects age and splenic sizes (14).

Another study conducted in Benin Teaching Hospital, Nigeria, shows the mean splenic length, width, depth, and volume for male subjects were found 11.1 cm, 4.4 cm, 7.8 cm, and 202.7 cm³, respectively. For the females the corresponding values of splenic length, width, depth, and volume were 10.1 cm, 4.0 cm, 7.1 cm, and 153.7 cm³, respectively. The study also shows the presence of strong correlation between subject height and weight with respective splenic dimensions for both sexes, but stronger for the males than females. There was no statistically significant correlation between splenic measurements and age and BMI of both male and female subjects (35).

A prospective study conducted on 108 volunteers in Khartoum, Sudan, showed that the mean values of the spleen length, width, thickness and volume were found to be 9.1 cm, 3.8 cm, 3.8 cm and 70.63 cm³ respectively. This study also showed significant positive correlation between the spleen size and volume and body parameters (height and weight), but age had no significant effect on spleen volume (28).

One study conducted on 708 individuals in the Arba Minch, Southern Ethiopia determined the mean splenic length, width, thickness and volume of 10.24 cm, 4.79 cm, 3.93 cm, and 109.34 cm³, respectively. Based on the sex groups different values were calculated, with the mean splenic length, width, thickness and volumes among males were 10.64 cm, 4.92 cm, 4.05 cm and 119.81 cm³ and among females were 9.75 cm, 4.63 cm, 3.78 cm and 96.50 cm³, respectively (36).

Researches conducted in the Northwest Ethiopia on 380 subjects; show that the mean splenic dimensions for men were 10.5 cm, 4.6 cm, 4.0 cm and 107.7 cm³ for splenic length, width, thickness, and volume, respectively, and for the women the mean values of splenic length, width, depth and volume were 9.4 cm, 4.0 cm, 3.6 cm and 78 cm³, respectively. For all gender the mean splenic length, width, thickness and volume were 9.95 cm, 4.3 cm, 3.8 cm and 92 cm³ respectively. Men had larger spleen sizes than women subjects. The splenic dimensions decreased with increase in age of adult subject in both sexes. These studies also demonstrated the correlation of spleen size with subjects' sex, height, weight, BMI and age. In women subjects, the spleen dimensions had positive correlation with subject's weight, height and BMI. In the men participants, only the spleen length and volume had significant positive correlation with the subjects' weight and BMI, but spleen thickness and width had no significant correlation with weight and BMI. However, it did not show significant correlation between subjects' height and splenic dimensions in men subjects (11, 17, 37, 38).

Therefore, the literature review shows that normal spleen dimensions vary within different individuals and across the different countries. The normal spleen dimensions have correlation with the sex, age, height, weight and BMI of the subjects.

3. CONCEPTUAL FRAMEWORK

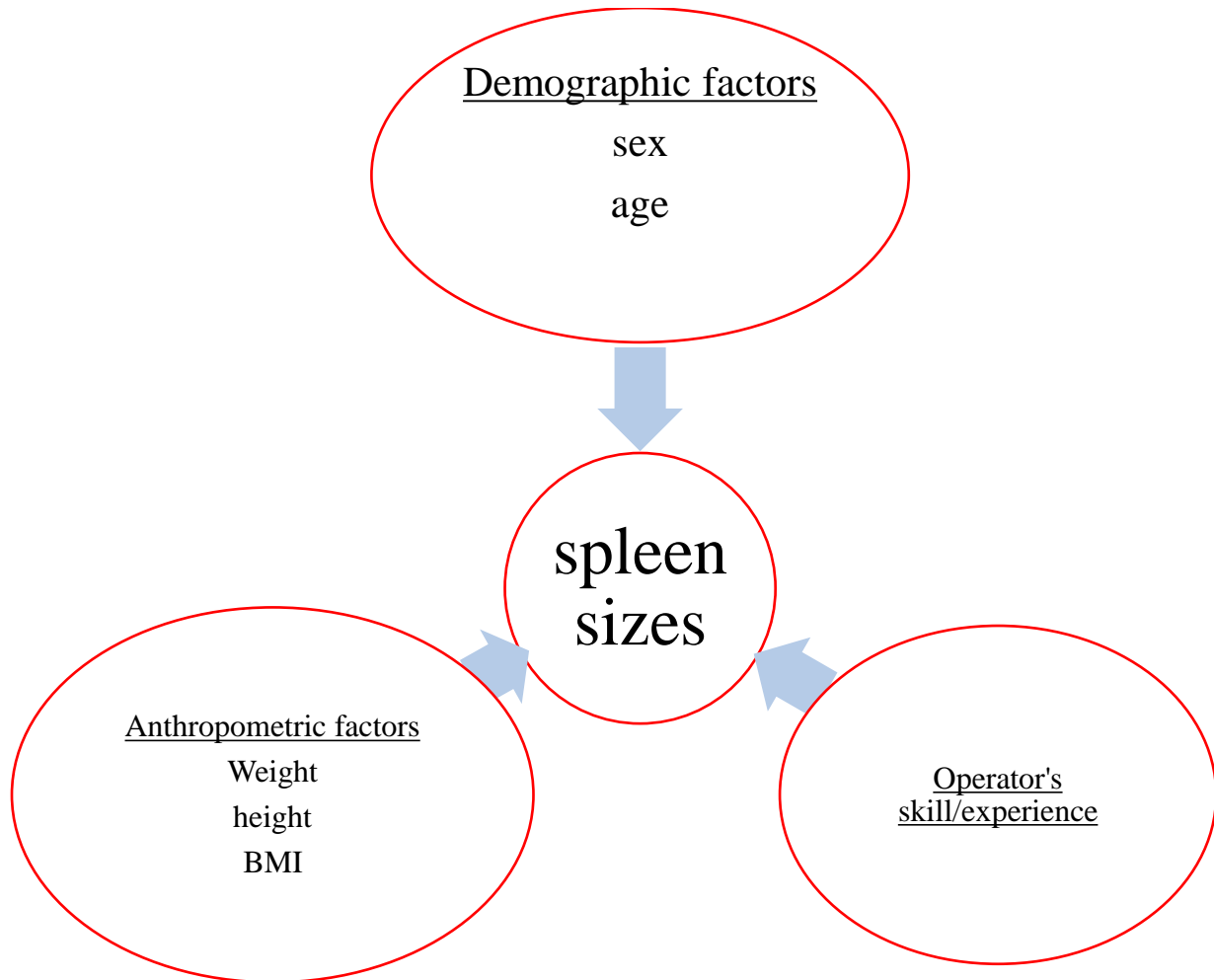


Figure 1- Conceptual frame work between spleen size and independent variable

CHAPTER TWO

OBJECTIVES

2.1 General objective

- to determine normal spleen sizes and associated factors by ultrasonography in adult population at TGSH during study period, February, 2021 to January, 2022.

2.2 Specific objectives

- to determine a baseline reference for normal spleen sizes by ultrasonography in adult population at TGSH during study period, February, 2021 to January, 2022.
- to assess the correlation between spleen sizes and associated factors in adult population at TGSH during study period, February, 2021 to January, 2022.

CHAPTER THREE

METHODOLOGY

3.1 Study area and period

The study was conducted at Bahir Dar University TGSB, which is found in the Bahir Dar, the capital city of Amhara regional state and located 578km Northwest of Addis Ababa. The city has three sub cities and 16 kebeles. The total population of the city stands at 750, 991 as of 2016 estimation. The city has two referrals, one district hospital, four private hospitals and six higher clinics and health centers owned by government and private sectors. TGSB is a teaching university hospital established in 2018 and has more than 350 beds for inpatient management and serving more than 8 million peoples from parts of Amhara and Benishangul Gumuz as inpatient and outpatient treatment. It is a training center for undergraduates and a wide spectrum for postgraduates. Currently, the department of clinical radiology has eight ultrasound machines and one X-ray machine. The department offers ultrasound, echocardiography, Doppler and X-ray diagnostic services and ultrasound guided procedures. The department also has 9 radiologists, 26 residents and six radiology technicians.

The study was conducted from February, 2021 to January, 2022.

3.2 Study Design –An institutional based cross-sectional study was conducted in adult population who had abdominal ultrasound scan at radiology department, BDU TGSB.

3.3 Populations

3.3.1 Source population- All adults who had normal abdominal ultrasound reports at department of radiology, BDU TGSB during study period.

3.3.2 Study population-selected adults with normal abdominal ultrasound reports and non-spleen related diseases at radiology department, BDU TGSB during study period.

3.4 Sample size and sampling technique

3.4.1 The sample size was determined using the formula designed for general population by considering 50% of maximum variability of spleen size within the population (P=0.5).

$n = Z^2 \times P(1-P) / d^2$; with CI 95% and margin of error 5% (0.05) $n = 384$ participants

Where;

n= sample size

z= Confidence interval of 95%=1.96

p= Proportion

d= Margin of error

Finally, by assuming 10% non-response rate, the final sample size **became 423**.

3.4.2 Sampling technique: -Simple random sampling technique was used to obtain the study participants. The first participant was selected randomly using lottery method.

3.5 Inclusion and exclusion criteria

3.5.1 Inclusion criteria- voluntary participants/patients age greater than 18yrs with normal abdominal ultrasound study and not known for spleen disease were included.

3.5.2 Exclusion criteria

- Individuals with a recurrent clinical history of malaria
- Individuals with a clinical history or laboratory evidence of infections (TB, typhoid fever, kala-azar, endocarditis, HIV AIDS)
- Splenectomy
- Individuals with any abnormal findings on abdominal ultrasound examinations (liver cirrhosis, lymphoma, metastasis, any cystic or LAPs, portal hypertension, ascites, solid massive lesions)
- Any splenic lesions on ultrasound scan (calcification, infarctions, lobulations, cysts, accessory spleen, and hemangioma) (39)
- Individuals with any lymphadenopathies
- Individuals with a history of heart disease, renal failure
- Hematologic disorders or anemia on clinical or laboratory findings
- Individuals with abdominal traumatic condition with suspicion of spleen injury
- Genetic diseases (thalassemia and sickle cell anemia)
- Malignant lesions

- Pregnant women (12, 40)

3.6 Variables and measurement

3.6.1 Dependent variables

- Spleen size

3.6.2 Independent variables

- Age
- Sex
- Weight
- Height
- BMI
- Operator skill
- Nutritional status
- Geographical location
- Physical activities (e.g., athletes)
- Genetic differences
- Race

3.7 Operational and term definitions

Normal abdominal ultrasound scan: when the abdominal ultrasound scan does not show any abnormal findings of all intrabdominal organs/structures including spleen in terms of size, echotexture and focal lesions.

Spleen: is the largest lymphoid organ located intraabdominally in the left upper quadrant of the abdomen.

Spleen length(L): is the maximum distance between the dome of the spleen and the splenic tip, measured in longitudinal plane at hilum.

Spleen width(W): the maximum distance between the medial and lateral borders of the spleen, measured in a plane perpendicular to the length at hilum.

Spleen thickness(T): is the maximum anteroposterior dimension, measured on the transverse section.

Volume of the spleen: product of length \times width \times depth \times 0.524. (This formula is frequently used for estimation of the volume of many irregularly shaped organs).

3.8 Data collection procedures

3.8.1 Data collection tools

The structured questionnaires and checklists were developed after revision of the literatures to document anthropometric data, ultrasonographic measurements and to include or exclude the participants into the study.

3.8.2 Data collection techniques

The participant was obtained from patients who came for abdominal ultrasound scan to the radiology department for different indications. Patients with clinical impression of non-spleen related diseases like nephrolithiasis, dyspepsia, lower urinary tract infection, nonmalignant gynecologic problems (e.g., infertility, dysmenorrhea, amenorrhea), hernia, hydrocele, BPH and those with no known splenic and liver diseases were possible candidates. Patients with known diagnosis of renal failure, cardiac diseases, hematologic diseases, infectious diseases (tuberculosis, malaria, kaalazar, schistosomiasis, HIV AIDS), any malignancy or any family history of genetic disorders related to spleen were excluded from the participation. The necessary clinical information of the patients was obtained from documented clinical diagnosis on the request paper, clinical history, physical examination and revision of the laboratory charts. First, the patients were scanned for the primary request and then all visceral organs (including spleen) evaluated thoroughly for gross pathologies. When the first scan appeared normal then the patient included in the study. Finally, when the combination of the patient's clinical diagnosis (clinical history, physical examinations and laboratory) and ultrasound scanning appeared normal the participant was enrolled into the study. The selected patients were involved in the study by simple random sampling techniques.

For all selected participants, all ultrasonographic studies were performed by Siemen's ultrasound machine with a curvilinear 2-5-MHz transducer (C5-2 probe). Two trained and experienced senior radiology residents performed all of the scanning with a radiologist in attendance. Additionally, the demographic data (e.g., age, sex) and anthropometric data (e.g., height, weight) were collected using structured questionnaire and standard anthropometric technique

respectively, then the body mass index (BMI) was calculated according to the formula $BMI = \text{weight}/\text{height}^2$. Then, the final data were documented on the prepared sheet.

Steps in data collection:

First, the patient who came for abdominal ultrasound was scanned for proper abdominal ultrasound scan for the requested indication. Every intrabdominal structures including spleen were thoroughly evaluated for any size changes and focal lesions to rule out any sonographic exclusion criteria.

Next, after abdominal ultrasound scan found to be normal, the patient was explained about the splenic examination to be done, its process and aim, to obtain his/her consent in this regard. Then, the participant was asked some questions and had physical examinations to rule out any clinical conditions or diseases related to spleen based on the prepared checklist.

After the screening was ok, the participant was asked for consent form. After agreement made, the sociodemographic and anthropometric data were documented, finally, the spleen sizes were measured according to the techniques below.

Ultrasonographic spleen size measurement was taken immediately after the screening, since no need for prior preparation of the subjects (4).

Techniques for ultrasound examination:

The volunteer participant was examined in the supine position for overall abdominal examinations to exclude cases associated with the spleen. Then, in supine or right oblique/decubitus positions, the spleen was examined and its dimensions measurements were performed for apparently healthy individuals and normal general abdominal scan. The spleen was scanned during suspended respiration(expiration). The splenic length was measured in a **longitudinal coronal plane** between the dome of the diaphragm and the inferior splenic tip at the 10th and 11th intercostal space through the splenic hilum which was identified by visualization of splenic vessels (mainly splenic vein). At the same time the splenic width was measured in a longitudinal plane perpendicular to the length between the medial (hilum) and lateral (convexity) borders of the spleen. Then, by rotating probe 90 degree to the longitudinal plane, the **transverse plan** was taken to measure the splenic thickness from the anterior margin

to posterior margin. Finally, the volume was calculated after the three measurements were recorded by using the ellipsoid formula during the analysis ($L \times W \times T \times 0.524$)(1, 4, 20, 26, 27).

The spleen dimensions were measured at least three times and the average value was recorded on the questionnaire sheet.

Finally, the standard anthropometric measurement of weight and height were taken and recorded on the questionnaire sheets.

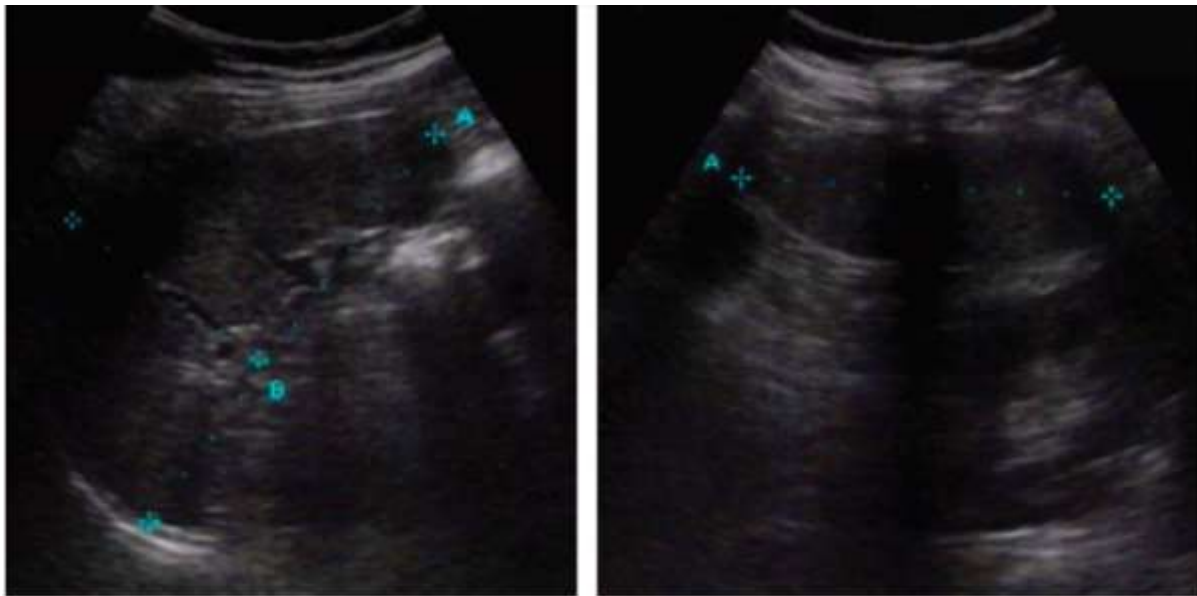


Figure 2 Illustrative measurement of spleen size with ultrasound.

Left image shows maximum spleen length and width and the right shows-anteroposterior spleen dimension at hilus (26).

3.9 Quality control

The quality of data was ensured through discussing and giving training /orientation on data collection procedures and techniques for data collectors one day before data collection. Written consent from participants for the survey was obtained immediately before ultrasound scan and confidentiality was assured to improve the quality of data.

During ultrasound measurements, quality of data was ensured by taking the spleen dimensions at least three times and recorded the average value on the questionnaire. Ultrasound measurements

were taken by two trained senior radiology residents under the supervision of radiologist thereby the quality of data improved.

Data consistency and completeness were checked throughout the work by principal investigator.

3.10 Data processing and analysis

Collected data by questionnaires were entered, cleaned and analyzed using IBM SPSS software version 23, & after analysis the results were presented by tables, graphs and descriptive and analytical measures. Relationship between spleen sizes and each of the variables were assessed with Pearson's correlation coefficient. R value of 0.2 and P value of less than 0.05 were used for analysis of correlation and statistical significance.

3.11 Ethical consideration

Before data collection an official written letter from Bahir Dar University, Institutional Review board (IRB) was obtained and submitted to the responsible hospital administration office. The participants were informed about the objectives of the study and the written consent was made with the full right not to participate in the study. Honesty and confidentiality were maintained throughout the study.

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3.12 Dissemination plan

The findings of this study will be disseminated by soft or hard copy, and communicated to stack holders (TGSH, other referral and district hospitals, and private clinics). Finally, the result will be presented on scientific meetings and conferences, and may also be published on scientific journals.

CHAPTER FOUR

RESULTS

4.1 Sociodemographic results

A total of 402 adults consisting of 185(46%) male and 217(54%) female were analyzed in the study whereas 21 participants were removed from analysis due to incomplete data. Of the participants, 51% and 49% were rural and urban residents, respectively [Figure-2].

The age range of the participants in this study was between 18 and 80 years with mean age of 37.67years and (± 14.9). The mean age for the males was 38.90 (± 16.89) years and that for the females was 36.62 (± 12.90) years. Age group 20–29years had the highest number of participants [Figure-3]. Other sociodemographic detailed in the table below [Table -1].

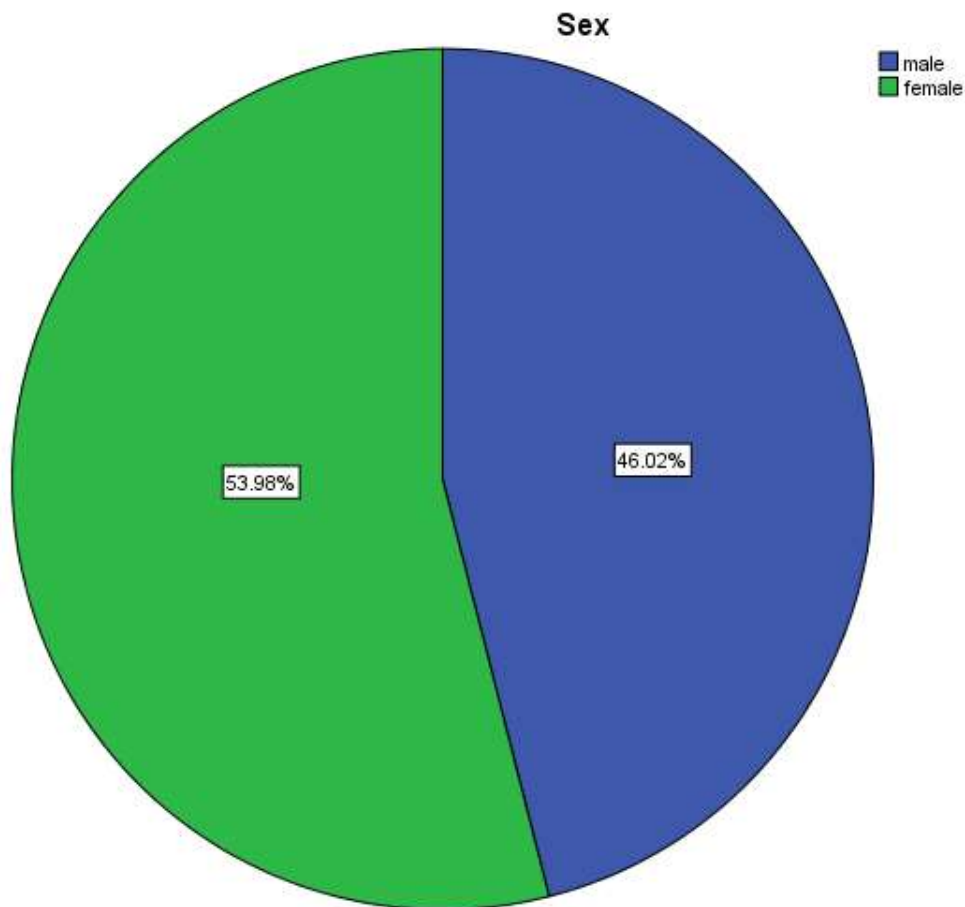


Figure 3- Pie chart demonstrating sex of the participants at TGSB, 2022.

Table 1- Demographic characteristics of the participants among adult population at TGSH, 2022.

Demographic characters		Frequency	Percentage (%)
Sex	Males	185	46
	Females	217	54
Residency	Rural	205	51
	Urban	197	49
Marital status	Married	305	75.9
	Single	81	20.1
	Divorced	6	1.5
	Widowed	10	2.5
Religion	Orthodox	377	93.8
	Muslims	20	5
	Protestants	5	1.2
Ethnicity	Ahmara	358	89.1
	Agew	41	10.2
	Others	3	0.7
Educational status	Uneducated	159	39.6
	Under grade 8	69	17.2
	Grade 9 – 12	50	12.4
	Diploma	26	6.5
	Degree and above	55	13.7
Occupational status	Farmers	122	30.3
	House wives	79	19.7
	Students	36	9
	Government employees	90	22.4
	Merchants	30	7.5
	Self-employees	20	5
	Others	25	6.2

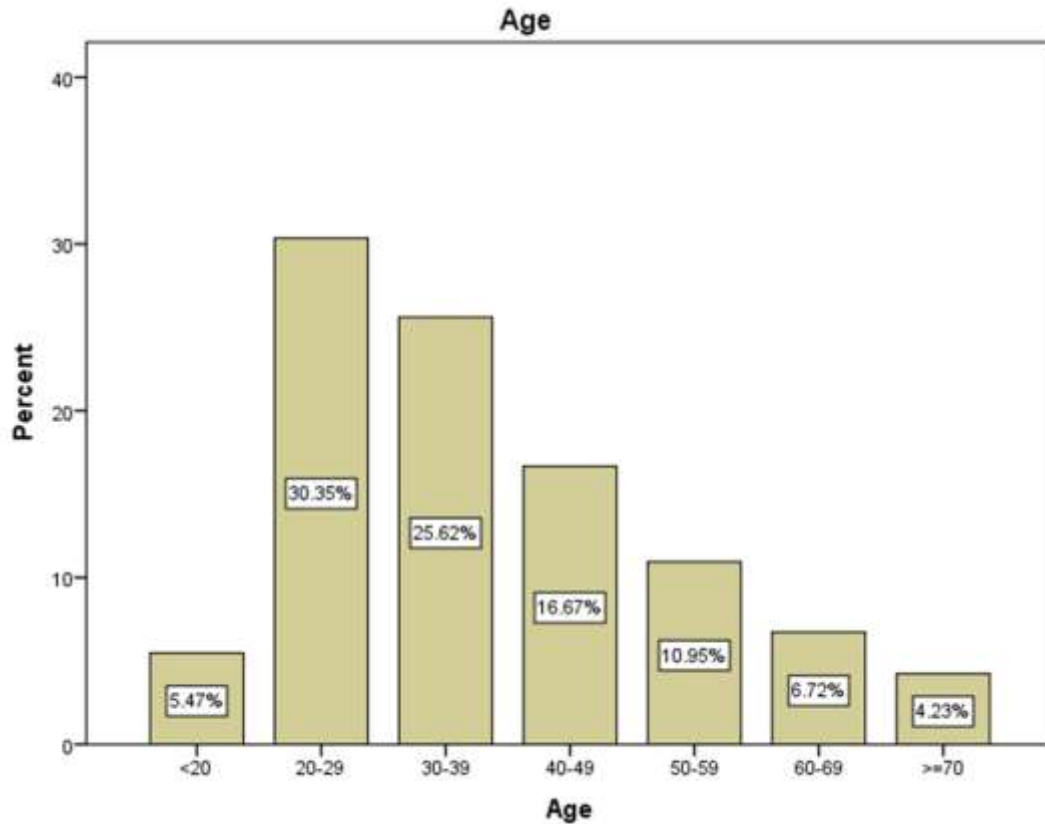


Figure 4 –Bar chart demonstrating age distribution of the participants at TGSB, 2022.

4.2- Anthropometric and splenic dimensions measurement

The mean height, weight and BMI of the studied participants and the standard deviation (\pm SD) were 162.5 cm (\pm 8.12), 54.91kg (\pm 9.64) and 20.76 (\pm 3.28), respectively. The mean height, weight and BMI for male group were 168.46cm (\pm 5.94), 57.42kg (\pm 8.89), 20.18 (\pm 2.77) kg/m², respectively; and for the female the corresponding values, mean height, weight and BMI were 157.39cm (\pm 5.97), 52.78kg (\pm 9.76), 21.26 (\pm 3.59) kg/m², respectively. The total range of height, weight and BMI of the participants were 140-185cm, 35-98kg and 13.3-40.3kg/m², respectively [Table-2].

Table 2- The comparison of mean, standard deviation, minimum and maximum measurements of weight, height and BMI of the all participants at TGSH, 2022.

Sex		Weight-kg	Height-cm	BMI
All gender	Mean	54.91	162.49	20.76
	Std. Deviation	9.64	8.12	3.28
	Minimum	35	140	13.3
	Maximum	98	185	40.3
Male	Mean	57.42	168.46	20.18
	Std. Deviation	8.89	5.94	2.77
	Minimum	38	153	13.3
	Maximum	90	185	31.2
Female	Mean	52.78	157.39	21.26
	Std. Deviation	9.76	5.971	3.59
	Minimum	35	140	15.6
	Maximum	98	172	40.3

The maximum splenic length, width, thickness and volume of the participants were 12.8cm, 4.7cm, 7.8cm and 244cm³, respectively. The minimum measurement of splenic length, width, thickness and volume for the studied participants were 7.1cm, 2.5cm, 5cm and 49cm³ respectively. The mean splenic length, width, thickness and volume for all gender were 10.35cm (± 1.16), 3.7cm (± 0.38), 6.72cm (± 0.44) and 136.7cm³ (± 35.29), respectively. For the male participants the mean splenic length, width, thickness and volume were 10.71cm (± 1.1), 3.82cm (± 0.36), 6.82cm (± 0.38) and 147.5cm³ (± 34.6), respectively; and for the females the corresponding values were 10.05cm (± 1.11), 3.6cm (± 0.36), 6.6cm (± 0.46), 127.4cm³ (± 33.3), respectively. Indicating that the mean splenic length, width, thickness and volume for females is lower than that for males [Figure-3].

Table 3-Comparison of the mean spleen dimensions measurement among male and female adult population at TGSH, 2022.

Sex		Length (cm)	Width (cm)	Thickness-cm	Volume-cm ³
Male (185)	Mean	10.71	3.82	6.82	147.49
	Std. Deviation	1.10	0.36	0.38	34.59
	Minimum	7.9	3.0	5.6	69.0
	Maximum	12.8	4.6	8.0	230.6
Female (217)	Mean	10.05	3.60	6.63	127.42
	Std. Deviation	1.11	0.36	0.45	33.27
	Minimum	7.1	2.5	5.0	48.8
	Maximum	12.8	4.7	7.8	244.0
All gender (402)	Mean	10.35	3.70	6.72	136.66
	Std. Deviation	1.16	0.38	0.44	35.29
	Minimum	7.1	2.5	5.0	48.8
	Maximum	12.8	4.7	8.0	244.0

The below table indicates that the splenic length, width, thickness and volume decrease with age increment for all gender. In similar fashion the splenic length, width, thickness and volume showed decrement with older age groups for both male and female subjects [Table-4&5].

Table 4-Comparison of mean splenic dimensions for different age groups of all gender among adult population at TGSH, 2022.

Age(years)		Length*	Width*	Thickness*	Volume**
<20	Mean	10.80	3.74	6.86	147.58
	Std. Deviation	1.35	0.37	0.51	40.10
20-29	Mean	10.67	3.78	6.79	144.82
	Std. Deviation	1.05	0.37	0.37	33.92
30-39	Mean	10.37	3.72	6.78	137.85
	Std. Deviation	1.02	0.33	0.39	31.29
40-49	Mean	10.23	3.68	6.69	133.72

	Std. Deviation	1.14	0.37	0.41	35.07
50-59	Mean	10.00	3.65	6.63	128.73
	Std. Deviation	1.19	0.39	0.38	35.19
60-69	Mean	10.11	3.62	6.66	128.63
	Std. Deviation	0.91	0.31	0.36	28.26
>=70	Mean	9.15	3.31	6.08	102.22
	Std. Deviation	1.59	0.54	0.79	48.38
Total	Mean	10.35	3.70	6.72	136.69
	Std. Deviation	1.16	0.38	0.44	35.37

NB: *=cm and ** =cm³

Table 5- Comparison of the mean splenic dimensions for the specific age groups among male and female adult population at TGSB, 2022.

Sex	Age(year)		Length*	Width*	Thickness*	Volume**
Male	<20	Mean	11.42	3.95	7.10	167.80
		Std. Deviation	1.02	0.19	0.37	28.47
	20-29	Mean	11.09	3.97	6.89	160.11
		Std. Deviation	1.01	0.37	0.34	34.42
	30-39	Mean	10.74	3.82	6.89	148.85
		Std. Deviation	0.93	0.33	0.33	28.98
	40-49	Mean	10.75	3.78	6.85	145.58
		Std. Deviation	0.91	0.26	0.24	25.66
	50-59	Mean	10.42	3.79	6.71	140.60
		Std. Deviation	1.24	0.39	0.37	36.99
	60-69	Mean	10.01	3.55	6.57	122.85
		Std. Deviation	0.87	0.29	0.32	25.80
	>=70	Mean	9.67	3.50	6.40	117.03
		Std. Deviation	1.43	0.43	0.59	45.60
Total	Mean	10.71	3.82	6.82	147.51	
	Std. Deviation	1.11	0.36	0.38	34.64	
Female	<20	Mean	9.911	3.433	6.511	118.367
		Std. Deviation	1.2946	.3640	.5036	37.1556

20-29	Mean	10.355	3.638	6.703	133.072
	Std. Deviation	.9754	.2971	.3658	28.6212
30-39	Mean	10.054	3.634	6.676	128.627
	Std. Deviation	.9872	.3112	.4068	30.3790
40-49	Mean	10.015	3.638	6.623	128.664
	Std. Deviation	1.1712	.4084	.4439	37.4889
50-59	Mean	9.577	3.518	6.545	116.859
	Std. Deviation	1.0170	.3514	.3814	29.5322
60-69	Mean	10.362	3.788	6.887	142.375
	Std. Deviation	1.0155	.3091	.3563	30.7849
≥70	Mean	8.200	2.967	5.500	75.067
	Std. Deviation	1.5414	.5989	.7975	44.3191
Total	Mean	10.047	3.603	6.628	127.456
	Std. Deviation	1.1149	.3628	.4584	33.3826

Note: - *=measurement in cm and **=volume measurement in cm³

4.3 Pearson correlation of splenic dimensions with other variables

The relationship between the splenic dimensions and the variables was done by Pearson correlation analysis. The splenic length, width, thickness and volume of the participants showed positive moderate significant correlation with weight, values ($r=0.31$, $p < 0.001$), ($r = 0.34$, $p < 0.001$), ($r = 0.39$, $p < 0.001$) and ($r = 0.35$, $p < 0.001$), respectively. There was positive significant correlation between the participants' height and splenic length ($r=0.32$, $p < 0.001$), width ($r=0.34$, $p < 0.001$), thickness ($r=.30$, $p < 0.001$), and volume ($r = 0.33$, $p < 0.001$). Weak positive correlation was found between participants' BMI and splenic length ($r = 0.14$, $P = 0.004$), width ($r = 0.17$, $P = 0.001$), thickness ($r = 0.25$, $P < 0.001$) and then with volume ($r = 0.18$, $p < 0.001$) [Table -6].

The relationship of splenic length, width, thickness and volume with age was also determined using Pearson correlation analysis. It showed negative significant correlation with values of ($r = -0.29$, $P < 0.001$), ($r = -0.22$, $P < 0.001$) and ($r = -0.27$, $P < 0.001$) and ($r = -0.25$, $p < 0.001$) respectively. The correlation between splenic dimensions and sex of the participants were determined and demonstrated negative significant correlation; length ($r = -0.29$, $P < 0.001$),

width ($r = -0.28$, $p < 0.001$), thickness ($r = -0.22$, $p < 0.001$) and volume ($r = -0.28$, $p < 0.001$) [Table-7].

Table 6-Pearson correlations between the splenic dimensions and anthropometric measurements among adult population at TGSH, 2022.

		Weight	Height	BMI	Length	Width	Thickness	Volume
Weight	Pearson Correlation(r)	1						
	Sig. (2-tailed)							
Height	Pearson Correlation	.462**	1					
	Sig. (2-tailed)	.000						
BMI	Pearson Correlation	.820**	-.114*	1				
	Sig. (2-tailed)	.000	.022					
Length	Pearson Correlation	.308**	.323**	.143**	1			
	Sig. (2-tailed)	.000	.000	.004				
Width	Pearson Correlation	.336**	.338**	.171**	.878**	1		
	Sig. (2-tailed)	.000	.000	.001	.000			
Thickness	Pearson Correlation	.388**	.296**	.253**	.838**	.837**	1	
	Sig. (2-tailed)	.000	.000	.000	.000	.000		
Volume	Pearson Correlation	.349**	.333**	.183**	.959**	.960**	.899**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Table 7- Pearson correlation of splenic dimensions with age and sex of adult population at TGSH, 2022.

		Age	Sex	Length	Width	Thickness	Volume
Age	Pearson Correlation	1					
	Sig. (2-tailed)						
Sex	Pearson Correlation	-.074	1				
	Sig. (2-tailed)	.138					
Length	Pearson Correlation	-.283**	-.286**	1			
	Sig. (2-tailed)	.000	.000				
Width	Pearson Correlation	-.218**	-.282**	.879**	1		
	Sig. (2-tailed)	.000	.000	.000			
Thickness	Pearson Correlation	-.271**	-.219**	.839**	.837**	1	
	Sig. (2-tailed)	.000	.000	.000	.000		
Volume	Pearson Correlation	-.250**	-.283**	.959**	.959**	.899**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	

** . Correlation is significant at the 0.01 level (2-tailed).

CHAPTER FIVE

DISCUSSION

The dimensional measurements of the visceral organs vary from person to person in normal individuals. Splenic dimensions measured by ultrasonography provides an objective and reliable way to assess spleen size(8). The findings from this study determined the normal mean and range of splenic dimensions and its correlation with participants' body parameters.

The mean height, weight and BMI of the current study were 162.5cm (\pm 8.12), 54.9 kg (\pm 9.64) and 20.76 (\pm 3.28), respectively. These findings are consistent with the result reported in North west Ethiopia (163.4cm (\pm 7.5) and 57.7 kg (\pm 9.4)(11, 17), Nigeria (164cm (\pm 7.7) and 61.4 kg (\pm 10.97) (14) and Sudan (163.1cm (\pm 17.75) and 65.33kg (\pm 15.43)(28) populations, but lower than that reported from study in the Canada (172 cm (\pm 0.58) and 76.3 kg (\pm 8.7))(27).

The overall normal mean of splenic length was 10.35cm (\pm 1.16) which is consistent with the studies conducted in Southern Ethiopia (10.24cm)(36), Northwest Ethiopia (9.95cm)(11), North Western Nigeria (10.2cm)(14), Russia (10.1cm)(34), Jordan (10.7cm)(25) and USA (10.65cm)(8). The reasons for consistence of the current study with other parts of Ethiopia were they share similar race, nutritional habitus, geographic location and body habitus (8, 10, 11, 28, 29), with that of western Nigeria were being black race and having comparable anthropometry(8, 27) and those of Jordan and Russia were share comparable anthropometry and similar highest number participants' age group(25, 34). But higher than the studies conducted in Sudan Khartoum (9.1cm)(28), Africa (8.9cm)(12), India (9.2cm)(2), Turkey (9.87cm)(13)); and lower than that of studies done in Nigeria (Benin) (11.1cm) and the size documented in American requisite series book(mean 11-12cm) (10, 35). These discrepancies may be due to the difference in age groups, nutritional status, geographic areas (including altitudes differences), physical exercises, anthropometric measurements, operator skills and measurement techniques, sample sizes and races (including black and white) as they stated in different literatures (8, 10-14, 16, 27-29, 41-44).

The normal mean splenic width of this study was 3.7cm (± 0.38) which is consistent with the study conducted in Southern Ethiopia (3.9cm)(36), Northwest Ethiopia (3.8cm)(11), Sudan (3.8cm)(28), and India (3.7cm)(2), but it was less than that of study conducted in Nigeria(northwest) (4.7cm)(14), Africa (4.9cm)(12), Jordan (4.4cm)(25), Russia (4.2cm)(34) and USA collegiate athletes (5.2cm) (8); and greater than that of study in Turkish adults(13). This value was also lower than the value (size) documented in requisite book series (USA) (4-5cm)(10). In similar fashion to the splenic length, the discrepancies may be due to the difference in age groups, nutritional status, geographic areas (including altitudes differences), physical exercises, anthropometric measurements, operator skills and measurement techniques, sample sizes and races (including black and white) as they stated in different literatures (8, 10-14, 16, 27-29, 41-44).

The overall normal mean splenic thickness [6.72cm (± 0.44)] and volume [136.7cm³ (± 35.29)] of this study were consistent with study conducted in Russia (T = 6.1cm and V = 141.2cm³)(34), this may due to their comparable anthropometric measurements and dominant age groups of this study with study in Russia(34). These findings were greater than that of study conducted in southern Ethiopia(4.79cm, V = 109.34 cm³)(36), Northwest Ethiopia (T=4.3cm, V = 92cm³)(17), Sudan T=3.8cm, V = 70.63cm³)(28) and Africa (T=5cm, V = 119.5cm³)(12); the identified reasons for these difference were different splenic thickness measurement), particularly from studies in Northwest Ethiopia, southern Ethiopia and Sudan; and operators (radiology technologists in study from southern Ethiopia)(11, 28, 36). But these values were less than from the study conducted in Nigeria (Northwest) (T=8.7cm)(14), Jordan (T=7.4cm. V=184cm³)(25), Turkey (T=7.6cm)(13) and India (T=8.2cm) (15), these can be explained that by the differences in geographic location, nutritional and body habitus, anthropometric measurement and races (our population were black and those from Jordan, Turkey and India were white races)(8, 10, 13, 27, 28, 41-44).

This study revealed different values of splenic dimensions among males and females. The mean normal splenic length, width, thickness and volume among male participants were 10.71cm (± 1.1), 3.82 (± 0.36), 6.82cm (± 0.38) and 147.5cm³ (± 34.6), and among the female participants were 10.05cm (± 1.11), 3.6cm (± 0.36), 6.6cm (± 0.46), 127.4cm³ (± 33.3), respectively. Overall, this indicated that all splenic dimensions were lower in female than male participants, which is

consistent with the studies conducted in Northwest Ethiopia, Sudan, Nigeria, Africa, Jordan, Turkey, India, Germany, and USA(2, 8, 11-14, 25, 26, 28). This can be explained by general truth that females have lower red blood volume (mass) circulating through spleen than their male's counterpart and other genetic factors (26, 36).

This study found that the spleen dimensions decrease as age increases, with mild decrease in up to the age of 70years after which it markedly decreases in both sexes [Table-4], which is consistent with studies conducted in the Northwest Ethiopia(38), Southern Ethiopia(36), Turkey(13) and India (Kosi region(15). This may be due to the aging process, which results in the decrement of the number and size of B cell follicles of the white pulp of the spleen which decreases with a decrease of germinal center of spleen, thus older people have a smaller mass of organs compared to younger subjects (36, 45, 46). However, it disagrees with the reports from Nigeria(14, 35), Africa (12), Sudan and Jordan studies(25, 28). This difference is probably due to nutritional status where larger anthropometric measurements and obesity were observed in the studies of Jordan and Nigeria(14, 25, 35).

In this study the spleen dimensions (L, W, T & V) had moderate positive correlation with participants' height and weight but weak positive with BMI, which were statistically significant ($p < 0.001$). These findings are consistent with the studies conducted in the Sudan(28), Nigeria (Benin and northwest), Jordan(25), Germany(26) and Canada(27). These may be due to taller, heavier and obese individuals have larger spleen dimensions their counter parts(10, 26). In contrast to this study, the study conducted in northwest Ethiopia reported the positive correlation between the splenic dimensions and weight, height and BMI of the women participants but only the splenic length and volume of the men participants had positive correlation with weight and BMI; the men height had no any correlation with splenic dimensions(11, 17, 37).

The normal mean splenic dimensions in this study had significant moderate negative correlation ($r < -0.2$, and $p < 0.001$) with the participants' age. This is consistent with study conducted in the Northwest Ethiopia, southern Ethiopia, Sudan, Turkey and India (13, 15, 28, 36, 38), but inconsistent with the reports from studies done in Nigeria (obese) and USA (taller) (8, 14, 35). This may be due to the aging process resulting in small organ mass in older age groups (45, 46).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The mean value of splenic length, width, thickness and volume of adult populations at TGSB were 10.35cm, 3.7cm, 6.72cm and 136.7cm³, respectively. The set of upper limits of the normal spleen sizes were 13cm, 5cm, 8cm and 250cm³ for length, width, thickness and volume, respectively. The single best dimension used to assess spleen size is length and in combination the spleen volume is most important in determining the splenomegaly. Males had larger spleen sizes than females. Spleen sizes (length, width, thickness and volume) had statistically significant positive correlation with weight, height and BMI of the individuals. In contrast to this the age of the participants had significant negative correlation with spleen dimensions.

6.2 Recommendations

The result of this finding contains the necessary data that can be used as a reference value for the clinicians and radiologists who are working in the region. During interpretations of the spleen dimensions considering the body parameters and other variables is very necessary.

For radiologists and radiology residents the values of spleen length and volume above 13cm and 250cm³ respectively, should need consideration and recommendation for further investigations and follow up.

Tibebe Ghion specialized hospital and other hospitals both government and all private clinics and hospitals in Bahir Dar city can incorporate the findings this study into their management and follow up of spleen related diseases.

For regional health bureau, FMOH and researchers; further future study is recommended by TGSH, FMOH and other health institutions in Ethiopia after filling the gaps identified in our study by extending this research and including data from other parts of the country.

Limitation of the study

Lack of specific confirmatory test to identify normal spleen, although splenic biopsy is confirmatory, it is not feasible.

Resource limitation to bombard the participants into all the necessary investigations to meet the exclusion criteria

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ANNEX- 1

QUESTIONNAIRE

Part-I Socio- Demographic Characteristics

1. MRN _____

2. Age _____

3. Sex 1. M 2. F
4. Ethnicity 1. Amhara 2. Agew 3. Tigre 4. Gumz 5. Others
5. Marital status 1. Single 2. Married 3. Divorced 4. Widowed
6. Resident 1. Urban 2. Rural
7. Religion 1. Orthodox Tewahidow 2. Muslim 3. Protestant 4. Others
8. Educational Status: 1. Uneducated 2. Less than grade 8 3. Grade 9-12 4. Diploma
5. Degree and above 6. Student 7. Others
9. Occupation: 1. Government employee 2. Students 3. Farmer 4. Self-employee 5. House
wife 6. Merchant 7. Others
10. athletes 1. Yes 2. No

Part II: Anthropometric measurements

1. Weight (kg)_____
2. Height (cm)_____
3. BMI_____

Part III: Sonographic spleen measurements

1. Splenic length(cm)_____
2. Splenic width(cm)_____
3. Splenic thickness(cm)_____
4. Volume (cm³) _____

Part -IV Exclusion criteria checklist

- 1- Do you have repeated malarial attack or treatment?
- 2- Do you have any bone swelling or pain?
- 3- Currently, do you have fever, cough, or SOB?
- 4- Are you taking any medications (like for HIV or TB)?

- 5- Do you have headache, lightheadedness, easy fatigability or tinnitus?
- 6- Do you have any active or previous bleeding history (AUB, epistaxis, UGIB, LGIB, gingival bleeding or any bleeding disorder)?
- 7- Do you have facial, abdominal or pedal swelling (from any causes like CHF, CLD, renal failure or hypoproteinemia) or are you taking treatment or follow up for the mentioned illness?
- 8- Pregnancy –yes, or no?
- 9- Do you have any known malignancy (on treatment or new dx) or focal swelling?
- 10- Do you have any neck, axillary or inguinal swelling (LAP)?
- 11- Do you have previous abdominal trauma or surgery that may injury or remove spleen?
- 12- Do you have family history of sickle cell anemia or thalassemia?
- 13- Abnormal findings on abdominal ultrasound examinations: -liver cirrhosis, lymphoma, metastasis, any cystic or LAPs, portal hypertension, ascites, solid massive lesions
- 14- Splenic lesions on ultrasound scan: - calcification, infarctions, lobulations, cysts, accessory spleen, and hemangioma
- 15- Any laboratory abnormality including CBC result (WBC, RBC, HG level), if done B/F, S/E, LFT....

ANNEX-2

CONSENT FORM

My name is Solomon Kebede (MD, 3rd Year Radiology Resident). I am training specialty in clinical radiology at Bahir Dar University. I am doing research on ultrasonographic

determination of normal splenic size among adult population, in partial fulfillment for the requirement of Clinical Radiology specialty in College of Medicine and Health sciences at Bahir Dar University, Department of Clinical Radiology. I will perform abdominal ultrasound for the measurement of spleen size and I am going to ask you some questions that are directly or indirectly affects the spleen sizes. If you agree, I will take sonographic measurement of your spleen sizes. Your name will not be documented in this form and the information you give are kept confidential. If you don't want to answer all of or some of the questions, you do have the right to reject. However, your willingness would be appreciated.

Would you like to participate in this study and answer all of the questions asked by investigator?

Yes_____

No_____

Name of data collector who sought the consent_____

Signature_____

Date of data collection_____

THANK YOU!

ANNEX-3

ASSURANCE OF INVESTIGATOR

I the undersigned resident agree to accept all responsibilities for the scientific and ethical conduct of the research project. I provided timely progress report to my advisors and seek the necessary advice and approval from my advisors in the course of the research. I had communicated timely to my advisors and all stakeholders involved in the study.

Name of the Resident: Dr. Solomon Kebede (MD, Radiology Resident)

Signature: _____

Date: _____

Approval of Advisors

Name of Advisor: Dr. Habtamu Tilahun (MD, Radiologist, Assistant professor in Radiology)

Signature: _____

Date: _____

Name of Advisor: Dr. G/Mariam Getaneh (MD, MPH, Assistant Professor of Health Systems and Project Management)

Signature: _____

Date: _____

Approval of advisors

We hereby certify that we have supervised, read, and evaluated this research thesis project entitled “Ultrasonographic determination of normal splenic size of adult population at Tibebe Ghion Specialized Hospital, by Solomon Kebede (MD, Radiology resident) prepared under our guidance. We recommend the research thesis project will be submitted for thesis defense.

Approval of Advisors

Name of Advisor: Dr. Habtamu Tilahun (MD, Radiologist, Assistant professor in Radiology)

Signature: _____

Date: _____

Name of Advisor: Dr. G/Mariam Getaneh (MD, MPH, Assistant Professor of Health Systems and Project Management)

Signature: _____

Date: _____