

ULTRASONOGRAPHIC EVALUATION OF SPLENIC VOLUME IN NORMAL, OBESE AND HYPERTENSIVE PATIENTS

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Abstract

Objective: To evaluate splenic volume in normal, obese and hypertensive patients by using ultrasonography

Study Design: Comparative Cross Sectional Study.

Place: Surraya Azeem Hospital Lahore, Pak Red Crescent Medical and Dental college and teaching Hospital

Duration of Study: 3 months

Methodology: A comparative cross-sectional study was conducted. A structured questionnaire will be used to collect demographic data and information on measurement of splenic volume in normal, obese and hypertensive patients by using ultrasonography.

Results: These are the main result of our investigation; utilizing ultrasonography, we found a statistically significant difference in splenic volume. Splenic volume in the normal, obese, and hypertension groups was compared in this study, which included 150 patients. The splenic volume of the Normal group is much larger than that of the Hypertensive and Obese groups, although the Hypertensive and Obese groups do not differ significantly from each other. This may suggest that, in comparison to normal people, obesity and hypertension are linked to decreased splenic volume.

Conclusion: Ultrasonography was found to be a practical, readily available, and non-invasive method for measuring splenic volume and size. The results indicate that the splenic volume is decreased in obese and hypertensive individuals when compared to normal individuals. Thus, obesity and hypertension may be linked to a reduction in splenic size. However, the splenic measures in the obese and hypertensive groups were quite similar.

Introduction

The adult spleen is an encapsulated organ weighing about 100-150g, roughly the size of a cupped hand, located in the left upper abdominal quadrant and separated posteriorly

from the pleura and ribs 9-11 by the diaphragm.¹ It is positioned between the diaphragm and the fundus of the stomach in the left hypochondrium of the abdominal cavity.² The spleen is connected to tail of the

pancreas and the left kidney by the splenorenal ligaments, which carries blood vessels to and from the spleen.³ The spleen is a slightly moveable, irregular wedge-shaped organ covered by a thin capsule and visceral peritoneum, with a convex outer surface facing the left diaphragm and a concave inner surface related to the stomach, pancreas and left kidney.⁴ The spleen is usually about 1 inch thick, 3 inches wide, and 5 inches long (2.5 x 7.5 x 12.5cm), but its size can vary from person to person.⁵ Obesity contributes to a higher risk of developing insulin resistance, type 2 diabetes, fatty liver disease, atherosclerosis, degenerative conditions such as dementia, respiratory disease, and certain cancers, these risks can be reduced through lifestyle changes like improved diet, regular physical activity, and smoking cessation, along with medical treatment such as statins, sometimes combined with niacin, bile acid sequestrants, or cholesterol absorption inhibitors.⁶ Hypertension, linked to cardiovascular diseases like heart disease and stroke, is a modifiable risk factor influenced by genetics, diabetes, obesity, and recently, the immune system.⁷ Ultrasound examination of the spleen is clinically important for assessing its position, measuring its size, and detecting tissue abnormalities when disease is suspected.⁸

Obesity and hypertension pose a risk of serious systemic and metabolic complications. This study aims to determine the relationship of splenic measurements and ultrasound derived spleen volume with age, sex, height, weight and BMI. The results may help to define normal reference values for spleen size and volume and to detect early changes associated with metabolic disorders, contributing to early diagnosis and improved clinical management.

Methodology

This comparative cross-sectional study was done in Surayya Azeem Hospital and Pak Red Crescent Medical and Dental College Teaching Hospital for the duration of three months. So, the study was done on 150 persons. Participants were selected using convenience sampling technique.

Inclusion Criteria

The participants were men and women over the age of 20 years. The study population included normal persons undergoing routine abdominal ultrasound examination, obese patients with body mass index (BMI) 30 kg/m² or more and hypertensive patients.

Exclusion Criteria

Patients younger than 20 years of age and those who were not cooperative during the ultrasound examination were excluded from the study.

Ultrasound examinations were performed with a Toshiba ultrasound machine and a low frequency (3.5-5.0 MHz) curvilinear probe. The patients were examined in the supine or right lateral decubitus position with the left arm raised above the head to spread the intercostal spaces. Ultrasound gel was applied to the left hypochondrium and the spleen was scanned in the left upper quadrant with a curvilinear probe. The transducer was positioned between 8th and 10th intercostal space on the posterior axillary line and directed to obtain the maximum longitudinal view of the spleen. Participants were asked to take a deep breath, hold it, and picture the spleen beneath the rib cage. The whole spleen was scanned including the superior dome and hilar region for any accessory spleen if present. The spleen length was recorded as the maximal pole to pole length in the longitudinal plane. The spleen width and thickness were recorded in the transverse plane. Measurements were taken to calculate and compare the volume of spleen in normal, obese and hypertensive subjects.

Patient Consent

Written informed consent was obtained from all individual participants included in the study and their data were used for research purposes.

Results

This study was conducted to evaluate splenic volume among normal, obese, and hypertensive individuals using Ultrasonography. A total of 150 participants were included in the study. The demographic and clinical variables analyzed were age, gender, splenic length, width, thickness, and splenic volume.

The study included 150 participants aged between 20 and 84 years, with a mean age of 42.55 ± 14.54 years. The mean dimensions of spleen were 10.61 ± 2.27 cm (length), 5.30 ± 1.51 cm (width) and 4.29 ± 0.95 cm (thickness). The mean volume of spleen was 149.72 ± 91.65 cm³. Mean spleen weight was 154.11 ± 92.00 g and mean splenic index was 268.34 ± 155.32 cm³. The sample consisted of 81 females (54%) and 69 males (46%) with no missing data. There was considerable variation in splenic volume and index between participants overall are shown in Table 1.

One hundred and fifty participants were included in the study. Fifty (33.3%) were normal and 100 (66.7%) were hypertensive or obese. 50 (33.3%) were obese and 100 (66.7%) were non-obese participants. Likewise, 50 (33.3%) participants were hypertensive and 100 (66.7%) were non-hypertensive. Therefore, the study population consisted of one third of obese and hypertensive each while the normal group consisted of 33.3% of the sample. This distribution provides an appropriate basis for comparison of splenic measurements and volume between normal and affected participants. All 150 participants were included in the analysis without missing data, providing complete representation and reliable statistical assessment. The distribution of normal and non-normal are shown in Figure:2. The bar chart shows the distribution of obese participants in the study. Out of the total 150 participants, 50 (33.3%) were categorized as obese, while 100 (66.7%) were classified as non-obese are shown in Figure 3: The bar chart shows the distribution of hypertensive participants in the study. Out of the total 150 participants, 50 (33.3%) were categorized as hypertensive, while 100 (66.7%) were classified as non-hypertensive are shown in Figure 4. The ages range from 20 to 84 years. The frequency counts show how many individuals fall into each age category. Percent represents the proportion of each age group relative to the total sample (150 people). Cumulative Percent shows the running total percentage up to that age. The most frequent age is 35 years with 14 individuals (9.3%), the highest count in the dataset. Other notable frequencies include ages 50 (8 individuals, 5.3%), 40 (6 individuals,

4%), and 45 & 55 (6 individuals each, 4%). Several ages have only 1 individual (0.7%), indicating sparse representation in some age brackets.. The bar chart shows the gender distribution of the participants. Out of 150 participants, 81 (54%) were females and 69 (46%) were males are shown in Figure 1. Splenic volumes ranged from 29 to 546 cm³, showing a wide variation. The majority of values were unique, but several values recurred. The distribution was right-skewed, with the majority of the volumes located between 29 and 150 cm³, which accounted for about 55.3% of the sample. Higher volumes were less common but ranged from 150 to 546 cm³ with some possible high volume outliers. The cumulative percentage rose gradually and reached 100% at 546 cm³.. The bar chart shows the distribution of splenic volume among the participants. The splenic volume ranged from 29 to 546 cm³, with a mean of 149.72 ± 91.65 cm³. are shown in figure 5.

Levene's test for equality of variances showed no significant difference in variances between groups ($F = 2.592$, $p = 0.110$), indicating homogeneity of variance. The t test for equality of means assuming equal variances resulted in $t(148) = 0.605$, with a p-value of 0.546, indicating no significant difference in splenic volume between the two groups. The mean difference between groups is 9.11 units, with a 95% confidence interval ranging from 20.62 to 38.84, which includes zero, further confirming the lack of significant difference. When equal variances are not assumed, the results are similar with $t(147.74) = 0.615$, $p = 0.539$ threshold are shown in Table 3.

The ANOVA test reveals a statistically significant difference in Splenic Volume between groups. The Between Groups sum of squares is 39,826.761 with 1 degree of freedom (df), and the Within Groups sum of squares is 1,211,616.517 with 148 df. The F-statistic is 4.865 with a p-value (Sig.) of .029, which is less than the 0.05 significance. The ANOVA test indicates a statistically significant difference in Splenic Volume between groups. The Between Groups sum of squares is 211,886.515 with 1 degree of freedom (df), and the Within Groups sum of squares is 1,039,556.763 with 148 df. The calculated F-statistic is 30.166 with a p-

value (Sig.) of .000, which is less than the common significance level of 0.05. The ANOVA analysis shows a statistically significant difference in Splenic Volume between groups. The Between Groups sum of squares is 67,987.898 with 1 degree of freedom (df), and the Within Groups sum of squares is 1,183,455.380 with 148 df. The F-statistic is 8.502 with a p-value (Sig.) of .004, which is below the 0.05 significance level. Shown in Table 4.

These are the overall finding of our study, we observed statistically significant difference in splenic volume by using ultrasonography. In this study, 150 patients were included to compare splenic volume in normal, obese, and hypertensive groups. Statistical analysis showed

that there was a statistically significant difference in the splenic volume among the study groups ($p < 0.05$). The mean spleen volume in the hypertensive group showed a statistically significant result ($p = 0.029$). The mean spleen volume in the normal group showed a highly statistically significant result ($p < 0.001$). The mean spleen volume in the obese group showed a highly statistically significant result ($p = 0.004$). The Normal group has significantly greater splenic volume compared to both Hypertensive and Obese groups, while there is no significant difference between the Hypertensive and Obese groups. This could imply that hypertension and obesity are associated with reduced splenic volume relative to normal individuals

Table 1. Descriptive Statistics of Age, Length, Width, Thickness and Splenic Volume

Variable	Total Participants	Min	Max	Mean	Std. Deviation
Age	150	20	84	42.55	14.536
Length	150	6	15	10.61	2.268
Width	150	3	8	5.30	1.510
Thickness	150	2	8	4.29	.947
Splenic Volume	150	29	546	149.72	91.646
Total Participants	150				

Table 1 denotes the descriptive statistics for 150 subjects are provided in table 1. The mean age was 42.55 ± 14.536 years, ranging from 20 to 84 years. The mean splenic measurements were 10.61 ± 2.268 cm for length, 5.30 ± 1.510 cm for width, and 4.29 ± 0.947 cm for

thickness. The mean splenic volume was 149.72 ± 91.646 , with values ranging from 29 to 546. As a general trend, the results demonstrate significant differences during the age and splenic volume of the studied subjects.

Table 2. Descriptive Statistics of Normal, Obesity and Hypertensive Patients

		Hypertensive	Obesity	Normal
Total Participants	Valid	150	150	150
	Missing	0	0	0
Mean		.33	.33	.33
Std. Deviation		.473	.473	.473
Minimum		0	0	0

Table 2 describes the mean value of 0.33 for hypertensive, obesity, and normal suggests that approximately 33% of the sample falls into each respective category. The standard

deviation of 0.473 indicates moderate variability around these means, consistent with binary variables where values are either 0 or 1.

Table 3. Comparison of Splenic Volume between the Two Groups

		Levene's Test for Equality of Variances				t-test for Equality of Means	
		F	t	df	Sig. (2-tailed)	Mean	Std. Deviation
Splenic Volume	Equal variances assumed	2.592	.605	148	.546	153.91	99.848
	Equal variances not assumed		.615	147.736	.539	144.81	81.419

Table 3 shows the two groups did not differ significantly in splenic volume as determined by the independent sample t-test. Under the assumption of equal variances, the mean difference was 153.91, with $t(148) = 0.605$, $p =$

0.546. Additionally, Levene's test was not significant ($F = 2.592$, $p > 0.05$) and the assumption of equal variances was not violated. So, the difference of splenic size was not statistically significant between the groups.

Table 4. Difference of Hypertension, Normal Status, and Obesity with Splenic Volume

Group	Source	Sum of Squares	df	Mean Square	F	Sig.
Hypertensive	Between Groups	39,826.761	1	39,826.761	4.865	.029
	Within Groups	1,211,616.517	148	8,186.598		
	Total	1,251,443.278	149			
Normal	Between Groups	211,886.515	1	211,886.515	30.166	<.001
	Within Groups	1,039,556.763	148	7,024.032		
	Total	1,251,443.278	149			
Obesity	Between Groups	67,987.898	1	67,987.898	8.502	.004
	Within Groups	1,183,455.380	148	7,996.320		
	Total	1,251,443.278	149			

A one-way Analysis of Variance (ANOVA) was performed to evaluate the difference of hypertension, normal status, and obesity with splenic volume as shown in Table 4. The results demonstrated statistically significant differences in splenic volume for all three comparisons. The hypertensive group showed a significant difference in splenic volume ($F(1,148) = 4.865$, $p = 0.029$). The normal group exhibited the strongest statistically significant difference ($F(1,148) = 30.166$, $p <$

0.001), while the obesity group also showed a significant difference ($F(1,148) = 8.502$, $p = 0.004$). Since all p-values were below the significance level of 0.05, the null hypothesis was rejected for each comparison. Overall, these findings indicate that hypertension and obesity were significantly associated with variations in splenic volume, and the comparison involving the normal group showed the greatest statistical difference among the three analyses.

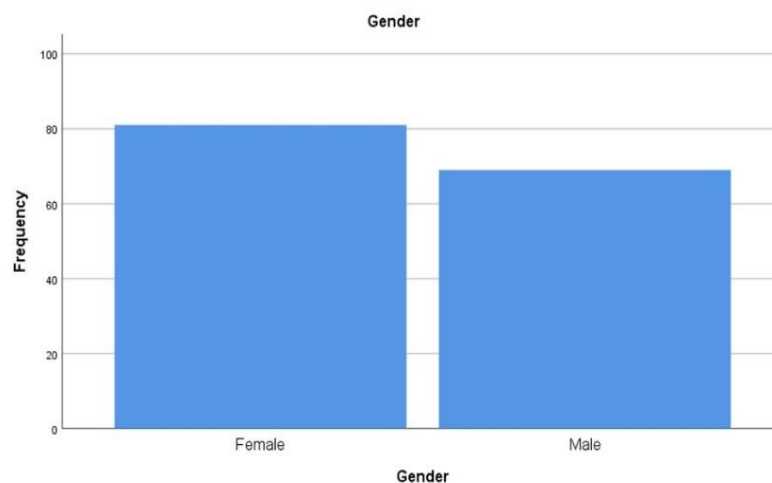


Figure 1. *Gender Distribution of the Participants*

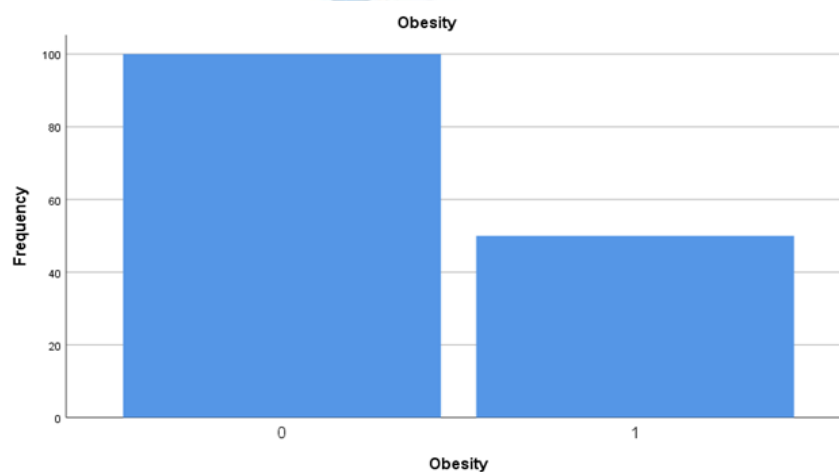


Figure 1 shows the bar chart depicting the gender distribution of the participants. Out of 150 participants, 81 (54%) were females and 69 (46%) were males.

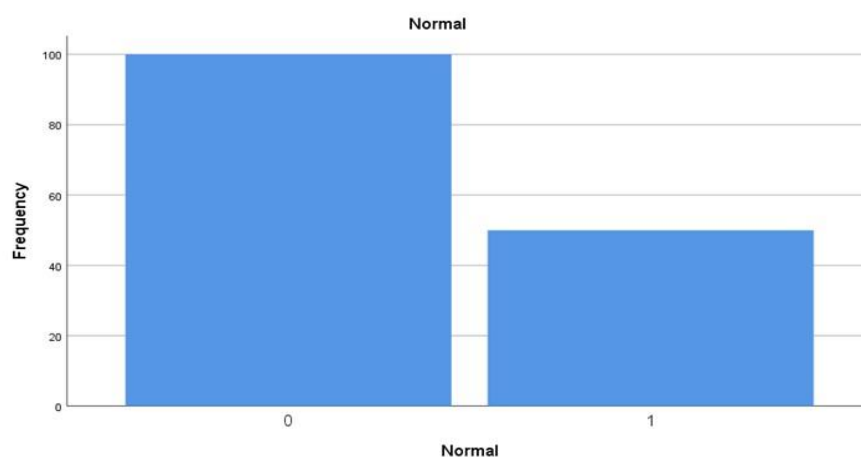


Figure 2. *Distribution of Normal Participants*

Figure 2 shows the bar chart shows the distribution of normal participants in the study. Out of the total 150 participants, 50 (33.3%) were categorized as normal, whereas 100 (66.7%) were classified as non-normal.

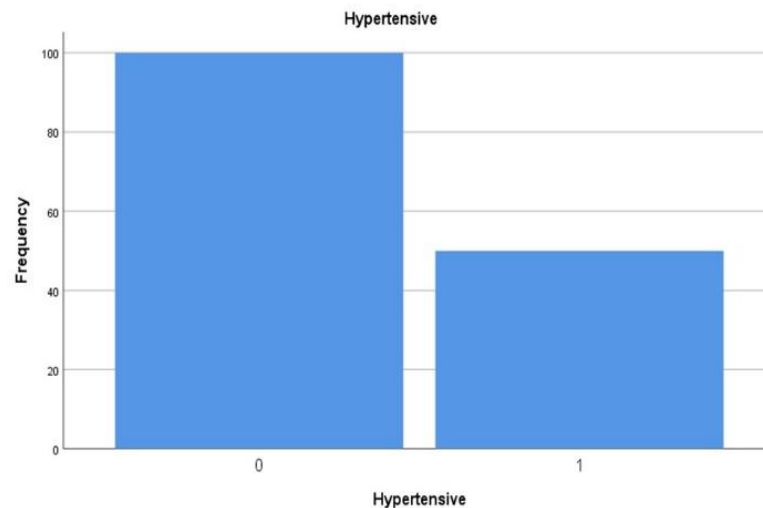


Figure 3.

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Figure 3 shows the bar chart showing the distribution of obese participants in the study. Out of the total 150 participants, 50 (33.3%) were categorized as obese, while 100 (66.7%) were classified as non-obese.

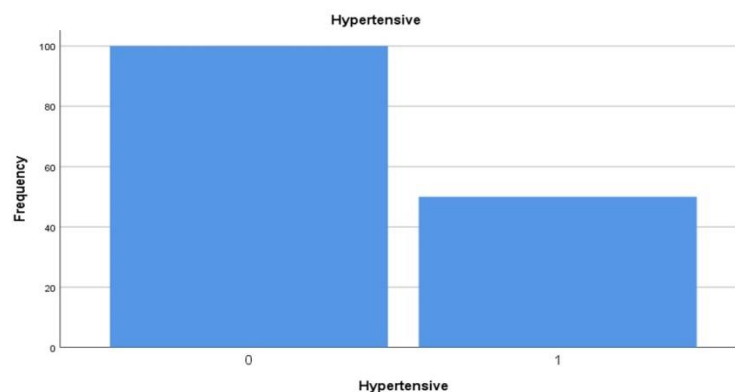


Figure 4. *Distribution of Hypertensive Participants*

Figure 4 denotes the bar chart showing the distribution of hypertensive participants in the study. Out of the total 150 participants, 50 (33.3%) were categorized as hypertensive, while 100 (66.7%) were classified as non-hypertensive

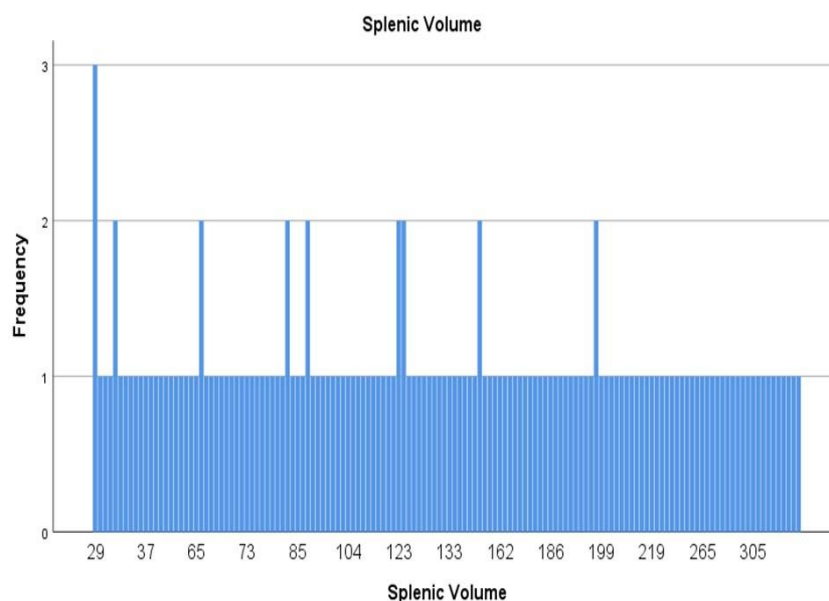


Figure 5. *Distribution of Splenic Volume among the Participants*

Figure 5 shows the bar chart shows the distribution of splenic volume among the participants. The splenic volume ranged from 29 to 546 cm³, with a mean of 149.72 ± 91.65 cm³

Discussions

This study included 150 patients to compare splenic volume among normal, obese and hypertensive patients. The analysis revealed a statistically significant difference in the splenic volume between the study groups ($p < 0.05$). Splenic volumes were highly significantly different in obese and normal patients and also statistically significant in hypertensive group versus other groups. Somnath Chakraborti, et al, Our study is comparable with the study done in Tripura in which the ultrasonography was used for assessment of spleen size in adults. The Tripura study measured the normal splenic length in healthy persons, whereas our study measured the splenic volume in normal, obese, and hypertensive subjects. Both studies support the use of ultrasonography as a reliable method of assessment of the spleen and provide valuable reference data for clinical practice. This study measured spleen length in 146 adults using ultrasonography. The spleen length ranged from 4.51 to 12.33 cm, with most individuals having values between 7 and 11 cm. The splenic length was slightly more in

male than female. Spleen length increased up to middle age, whereas it decreased in older age groups. Age was significantly negatively correlated with splenic length and ANOVA analysis showed significant differences between age groups ($p = 0.024$). The study reveals that splenic length is affected by age and sex.⁹ Our study included 150 patients to compare splenic volume among normal, obese and hypertensive patients.

The analysis revealed a statistically significant difference in the splenic volume between the study groups ($p < 0.05$). Splenic volumes were highly significantly different in obese and normal patients and also statistically significant in hypertensive group versus other groups. Doktor der Medizin, et al are of the view that the study can be directly compared to the Study of Health in Pomerania, which investigated the association between obesity and hypertension with splenic volume. Both studies had found that change in splenic volume was related to obesity (though populations and methods differed), and hypertension. This study showed that spleen volume had a positive relationship with the parameter of systolic blood pressure, pulse pressure and body composition. Body weight and BMI were associated with spleen volume in both sexes, and the fat-free mass was associated in a similar way. The associations were stronger in men. The results indicate that

the size of spleen is affected by cardiovascular and metabolic factors. In addition, our results are corroborated by a separate SHIP-analysis of independent associations of central obesity and fat-free mass with larger spleen volume¹⁴ and by a recent case-control study that found higher ambulatory diastolic BP in splenectomized patients compared to matched controls, which provides the first direct evidence in humans that splenic tissue is associated with blood-pressure regulation in addition to its influence on hypertension. Several other sonographic studies have been conducted which support this reference value interpretation: splenic size and splenic volume have both been found to be correlated with anthropometric parameters, such as height, weight, and BMI, in both the Kurdistan¹² and the Iraqi cohorts,¹³ and a large healthy German population of 1,200 patients established normal splenic size by body height and sex,¹¹ in line with the approach used in the present study.

Conclusion

Ultrasonography was found to be a practical, readily available, and non-invasive method for measuring splenic volume and size. The results suggest that factors such as obesity and hypertension could influence the splenic measurements but the statistical differences observed in the analyzed. Normal group has significantly greater splenic volume compared to both Hypertensive and Obese groups, while there is no significant difference between the Hypertensive and Obese groups. This could imply that hypertension and obesity are associated with reduced splenic volume relative to normal individuals

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Conflict of Interest:

The authors declare that they have no conflicts of interest.

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Transparency Statement

The authors confirm that this manuscript provides an honest, accurate, and transparent report of the study. No important aspects of the study have been omitted, and any differences from the original study plan have been explained.

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