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SONOGRAPHIC EVALUATION OF SPLENIC INDEX IN 2ND AND 3RD TRIMESTER IN OBESE AND NON-OBESE PATIENTS

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Abstract

Objective: *To determine the splenic index in 2nd and 3rd trimester in obese and non-obese patients on ultrasound*

Methods: *A Comparative Analytical study of splenic index was conducted at university ultrasound clinic, Lahore in period of four months. Total 600 female patients were examined in which 122 obese females and 478 non-obese females were included aged between 17-45 years by convenient sampling technique. Mindray and Toshiba Ultrasound Machines were used to perform the ultrasonography. Data is comprised of Qualitative and Quantitative variables (Age, Gestational Age, obese and non-obese women). The quantitative data will be presented in the form of mean, SD and qualitative data will be presented in independent t-test evaluated and analyze with SPSS version 25.*

Results: *The study found a significant positive correlation between gestational age and splenic index ($r = 0.1892$, $P < 0.0001$), as well as between age and splenic index ($r = 0.1778$, $P < 0.0001$) in a sample of 600 patients. Comparing splenic measurements between obese and non-obese groups revealed that obese patients had significantly higher splenic index, splenic width, and splenic length, underscoring the influence of obesity on splenic size during the 2nd and 3rd trimesters.*

Conclusion: *study shows that splenic dimensions increase with gestational age.*

Introduction

The spleen acts as the filter for the blood and perform immunological functions.(1) The spleen, a lymphoid mass, is located behind the 9th and 11th ribs in the left hypochondriac area of the abdominal cavity where part of it is in the epigastric area.[2] Therefore, the largest lymph organ is located between the stomach fundus and the diaphragm. As a highly vascular organ, the spleen is spongy and reddish-purple in color.[3] An adult human spleen is approximately the size of a clenched fist, though it varies in size and weight, measuring approximately 10-12 cm in the longest axis,5cm thick and 7cm wide[4] and weighing 150-200 grams on average (2, 3) Frequently, the spleen's size can change while it carries out its duties, which include removing bacteria and particle antigens from the blood, eliminating old or damaged red blood cells from circulation, and producing immunoglobulin. Furthermore, the spleen is the source of hemopoiesis and stores platelets in fetuses.(4)A typical pregnancy affects the body's systems and organs in a physiological way. In order to nourish the growing fetus and meet the metabolic needs of the mother, pregnancy causes significant physiological changes in the female body(5).

Splenomegaly is characterized by enlarged spleen and is not the same as hypersplenism, which is hyperactive spleen.(2)Splenomegaly can impair the

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spleen's normal functions, including its ability to filter blood and its role in immune responses. This can lead to increased susceptibility to infections, anemia caused by excessive breakdown of red blood cells, and potential complications related to splenic rupture in severe cases.

Obesity defined by WHO as abnormal and excessive fat accumulation that might impair health. This condition is also defined by BMI of 30kg/m^2 or more.(6) The prevalence of obesity in united states is approx. 40% and pre-pregnency prevalence of obesity is 30%.(7) Pre-pregnancy obesity poses challenges to maternal health due to associated risks such as gestational diabetes, hypertension, insulin resistance, sub-fertility, miscarriage, congenital abnormalities and increased susceptibility to infections.(8)

Ultrasonography is a cheap, non-ionizing and reliable imaging technique that provides reducible results. A deeper understanding of how splenic dimensions change in different trimesters of pregnancy, along with a comparison between obese and non-obese patients, provides valuable insights into potential complications. This knowledge can help in distinguishing physiological adaptations from pathological conditions, improving diagnostic accuracy and maternal care.

Methods:

This comparative study was conducted for 4 months. Informed written consent was obtained from all eligible study participants before their inclusion in the study. Study was conducted after the approval from Research Ethical Committee, REC # 92 The University of Lahore. Total 600 female patients were examined in which 122 obese females and 478 non-obese females were included aged between 18-45 years by convenient sampling technique. Females with abnormal pregnancies and unhealthy pregnant females were excluded. Mindray and Toshiba Ultrasound Machines were utilized in conducting the ultrasonography. A 3.5 MHz frequency probe was utilized; scanning was done in deep inspiration in supine position. The sonographer locates the spleen by finding the left upper quadrant of the abdomen. The spleen is normally located between the 9th and 11th ribs, from the mid-axillary line to the midclavicular line. Length of spleen was taken in a longitudinal projection from superior to inferior pole. The width of spleen was taken in a transverse projection at the maximum point. The measurements of length and width taken were noted on data collection forms. Splenic index was then calculated by standard formula (length*width). Data comprised pregnant women with a gestational age of 13 weeks to full term (≥37 weeks) at the time of ultrasound evaluation. Data consists of nominal (obese and non-obese) and Quantitative variables such as Age (years), length (cm), width (cm) and Gestational Age (weeks). The quantitative results are given as mean, SD and qualitative results are given in independent t-test assessed and examined with SPSS version 25.

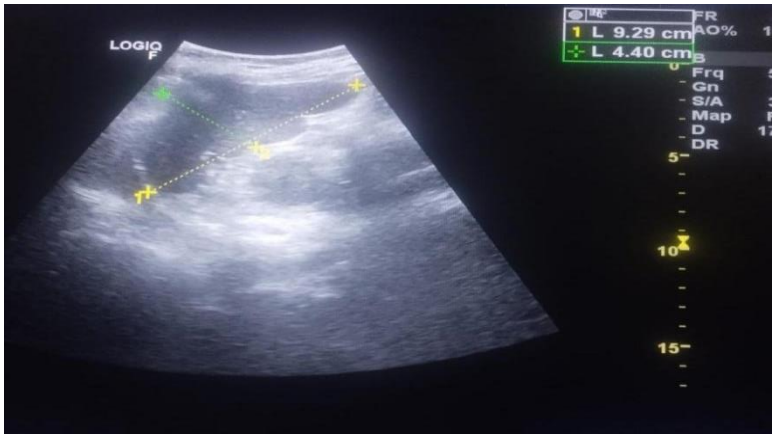

Figure 1 shows the length and width of spleen.

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Results

An analysis of 600 individuals was conducted to assess the correlation between splenic index and gestational age. The splenic index and gestational age showed a small but statistically significant positive connection ($r = 0.1892$, $p < 0.0001$), with a 95% Confidence interval of 0.1108 to 0.2652. This indicates a slight increase in splenic index as gestational age progresses.

Furthermore, an independent samples t-test was performed to compare splenic index between normal-weight and obese individuals. The analysis included 478 normal-weight participants and 122 obese participants. The mean splenic index was significantly higher in the obese group (69.2161 ± 7.4808) compared to the normal-weight group (42.4658 ± 9.5812), with a mean difference of 26.7503 (95% CI: 25.1610 to 28.3397). The Welch t-test, accounting for unequal variances, demonstrated a highly significant difference between the groups ($t = 33.160$, $DF = 233.2$, $p < 0.0001$).

Additionally, there was a significant difference in the variance of the splenic index across the groups (F-test, $p = 0.001$). The results of the Shapiro-Wilk test ($W = 0.9916$, $p = 0.0017$) supported the observed differences by showing a deviation from residual normality. According to these results, there may be a connection between body weight and spleen size, as obesity is linked to an elevated splenic index.

TABLE 1
Correlation

Variable Y	Splenic_Index Splenic Index
Variable X	Gestational_age Gestational age
Sample size	600
Correlation coefficient r	0.1892
Significance level	P<0.0001
95% Confidence interval for r	0.1108 to 0.2652

Above table shows positive correlation between Gestational age and Splenic Index among the 600 samples studied (r = 0.1892, 95% CI [0.1108, 0.2652], P < 0.0001). This indicates that as Gestational age increases, there tends to be a slight increase in Splenic Index.

TABLE 2
Independent samples t-test

	Sample 1	Sample 2
Sample size	478	122
Arithmetic mean	42.4658	69.2161
95% CI for the mean	41.6047 to 43.3269	67.8753 to 70.5570
Variance	91.7988	55.9630
Standard deviation	9.5812	7.4808
Standard error of the mean	0.4382	0.6773
F-test for equal variances	P = 0.001	

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Above table shows significant difference in Splenic Index between the Normal weight and Obese groups. The Obese group (mean = 69.2161, 95% CI [67.8753, 70.5570]) exhibited a significantly higher Splenic Index compared to the Normal weight group (mean = 42.4658, 95% CI [41.6047, 43.3269]), with a p-value below the conventional threshold of 0.05. Additionally, an F-test for equal variances indicated unequal variances between the groups (P = 0.001)

TABLE 3
Welch-test (assuming unequal variances)

Difference	26.7503
Standard Error	0.8067
95% CI of difference	25.1610 to 28.3397
Test statistic t(d)	33.160
Degrees of Freedom (DF)	233.2
Two-tailed probability	P < 0.0001

Residuals

Shapiro-Wilk test for Normal distribution	W=0.9916 reject Normality (P=0.0017)

Above table shows unequal variances between groups, revealed a highly significant difference in Splenic Index between the Normal weight and Obese groups. The Obese group demonstrated a significantly higher mean Splenic Index (69.2161, 95% CI [67.8753, 70.5570]) compared to the Normal weight group (42.4658, 95% CI [41.6047, 43.3269]), with a substantial mean difference of 26.7503 (95% CI [25.1610, 28.3397]). The test statistic (t = 33.160) was associated with a very small p-value (P < 0.0001), indicating a robust rejection of the null hypothesis of no difference in Splenic Index between the groups.

TABLE 4
Correlation

Variable Y	Splenic_Index Splenic Index
Variable X	Age Age

Sample size	600
Correlation coefficient r	0.1778
Significance level	P<0.0001
95% Confidence interval for r	0.09918 to 0.2542

Above table shows the analysis of data from a sample of 600 individuals reveals a statistically significant positive correlation between Age and Splenic Index (r = 0.1778, 95% CI [0.09918, 0.2542], P < 0.0001). This indicates that as individuals' Age increases, there is a slight tendency for their Splenic Index to also increase.

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TABLE 5

Sample 1		
Variable	Splenic_width_cm_ Splenic width (cm)	
Filter	Obese\non_obese="Normal"	
Sample 2		
Variable	Splenic_width_cm_ Splenic width (cm)	
Filter	Obese\non_obese="Obese"	
Standard error of the mean	0.03316	0.04891

Independent samples t-test

Above table shows the comparison of Splenic width between individuals categorized as Normal weight and Obese using Welch's t-test revealed a statistically significant difference. The Obese group exhibited a mean Splenic width of 5.8720 cm (95% CI [5.7751, 5.9688]), which was notably higher than the mean of 4.4207 cm (95% CI [4.3556, 4.4859]) observed in the Normal weight group.

	Sample 1	**Sample 2**
Sample size	478	122
Arithmetic mean	4.4207	5.8720
95% CI for the mean	4.3556 to 4.4859	5.7751 to 5.9688
Variance	0.5255	0.2918
Standard deviation	0.7249	0.5402
F-test for equal variances	P < 0.001	

TABLE 6

Welch-test (assuming unequal variances)

Difference	1.4513
Standard Error	0.05909
95% CI of difference	1.3349 to 1.5676
Test statistic t(d)	24.561
Degrees of Freedom (DF)	244.7
Two-tailed probability	P < 0.0001

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Residuals	
Shapiro-Wilk test for Normal distribution	W=0.9905 reject Normality (P=0.0006)

Above table shows the analysis using Welch's t-test to compare Splenic width between Normal weight and Obese groups revealed a highly significant difference. The Obese group exhibited a mean Splenic width of 5.8720 cm (95% CI [5.7751, 5.9688]), which was notably larger than the mean of 4.4207 cm (95% CI [4.3556, 4.4859]) observed in the Normal weight group. The calculated mean difference between the groups was 1.4513 cm (95% CI [1.3349, 1.5676]), with a test statistic of 24.561 and a p-value of less than 0.0001, indicating a robust rejection of the null hypothesis of no difference.

TABLE 7

Summary statistics table

	Age	Gestational age
N	600	600
Minimum	17.000	13.000
Maximum	45.000	40.000
Mean	27.795	28.520
Median	28.000	29.000
SD	5.1514	6.6072

	Sample 1	Sample 2
Sample size	478	122
Arithmetic mean	9.5210	11.8074
95% CI for the mean	9.4302 to 9.6119	11.6401 to 11.9746
Variance	1.0217	0.8706
Standard deviation	1.0108	0.9331
Standard error of the mean	0.04623	0.08448

Above table shows the summary statistics for Age and Gestational age based on a sample of 600 observations provide insights into the distribution and central tendencies of these variables.

TABLE 8

Independent samples t-test

Sample 1	
Variable	Splenic_length_cm_ Splenic length (cm)
Filter	Obese\non_obese="Normal"
Sample 2	
Variable	Splenic_length_cm_ Splenic length (cm)
Filter	Obese\non_obese="Obese"

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F-test for equal variances	P = 0.287

Above table shows the comparison of Splenic length between Normal weight and Obese groups using an independent samples t-test revealed a significant difference in mean values. The Obese group displayed a substantially higher mean Splenic length of 11.8074 cm (95% CI [11.6401, 11.9746]) compared to the Normal weight group, which had a mean of 9.5210 cm (95% CI [9.4302, 9.6119]).The F-test for equal variances showed no significant difference in variances between the groups (P = 0.287), validating the use of a t-test assuming equal variances

TABLE 9

T-test (assuming equal variances)

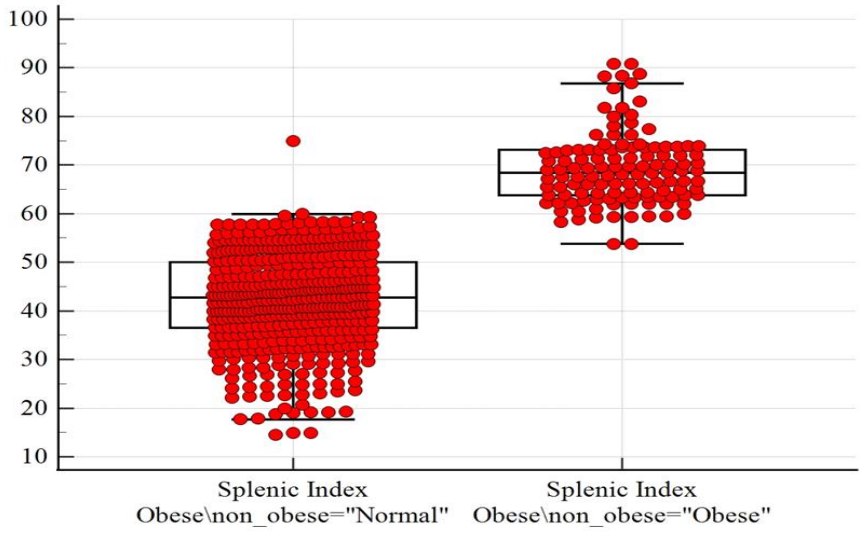
Difference	2.2864
Pooled Standard Deviation	0.9956
Standard Error	0.1010
95% CI of difference	2.0880 to 2.4847
Test statistic t	22.641
Degrees of Freedom (DF)	598
Two-tailed probability	P < 0.0001

Residuals

Shapiro-Wilk test for Normal distribution	W=0.9916 reject Normality (P=0.0017)

Above table shows the test statistic (t = 22.641) was associated with a very small p-value (P < 0.0001), indicating a robust rejection of the null hypothesis of no difference.

Graph



Graph shows the difference in splenic index of obese and non obese patients

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Discussion

This study compared the splenic index of 600 female patients, comprising 122 obese and 478 non-obese women aged 18-42 years, to determine the effect of obesity on spleen size. Both qualitative and quantitative variables were assessed using a suitable sampling strategy, quantitative variables were presented as mean ± SD, while qualitative data were assessed using an independent t-test.

The findings showed that obese and non-obese women had significantly different spleen sizes, indicating that obesity may be a contributing factor to splenic enlargement because of changes in hemodynamics and systemic circulation.

Ultrasound is an especially efficient imaging modality for assessing abdominal organs and also is considered the safest technique for use during pregnancy. Its completely non-invasive nature and entirely high-resolution imaging capabilities make it exceptionally useful when assessing all physiological changes in the spleen during pregnancy. During gestation, dynamic spleen changes occur because of hemodynamic adaptations, hormonal fluctuations and maternal body composition. Additionally, conditions such as infections, malignancies, hematologic disorders, and liver diseases can contribute to spleen enlargement during pregnancy.

This study thoroughly targeted evaluating the thorough effect of obesity on each splenic dimension throughout the second trimester as well as the third trimester of pregnancy. A strong link between obesity and greater spleen size was obvious because obese pregnant women had spleens that were greatly larger than those of pregnant women who were not obese. The analysis confirmed a positive correlation between gestational age and splenic index, as well as between splenic index and obesity, indicating that splenic dimensions tend to increase with both pregnancy progression and higher BMI.These results align with earlier research by Maymon et al. (2006), who also reported a positive correlation linking gestational age to splenic dimensions and pre-pregnancy BMI to splenic size(9)

In a study by Benjamin et al., (2021), it was found that splenic length, width, thickness, and volume increased progressively with gestational age.(4) Similar findings were observed in this study, where splenic dimensions increased with advancing gestational age.

Furthermore, Gul et al. (2018) reported significant correlations between spleen dimensions and BMI, reinforcing the findings of this study that obesity plays a crucial role in determining splenic size.(10)

In this study, the independent samples t-test in this study revealed a significant difference in splenic index between obese and non-obese groups. Obese individuals had a notably higher mean splenic index (69.22) compared to non-obese individuals (42.47). This was further confirmed by Welch's t-test, which indicated a statistically significant mean difference of 26.7503 between the two groups ($P < 0.0001$). Additionally, a significant positive correlation ($r = 0.1778$) was observed between maternal age and splenic index, reinforcing the hypothesis that age and obesity contribute to splenic size variations.

Solomon et al. (2021) conducted a morphometric assessment of splenic dimensions and found a positive correlation between age and splenic size, particularly in the 21-40 age group.(11) This study's findings are in agreement, suggesting that age-related changes contribute to splenic adaptation during pregnancy.

Although these findings are important, this study has certain limitations. The study did not take into consideration potential confounding variables like as genetic predispositions, eating habits, or maternal comorbidities. Variations in ultrasonic measuring methodologies, as well as operator reliance, might possibly have impacted the findings. To further confirm these findings, future research should include a broader and more expanded population.

This study concludes that obesity has a significant effect on splenic dimensions during pregnancy, especially during the second and third trimesters. The findings highlight the need for further research into the physiological effects of splenic variations in obese pregnant women by indicating that obesity may have a role in splenic enlargement.

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Conclusion

The study concluded that obesity is associated with an increase in splenic dimensions during the 2nd and 3rd trimesters, highlighting the impact of obesity on splenic size during pregnancy.

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