



Advanced Ultrasound

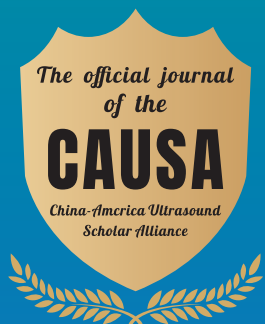
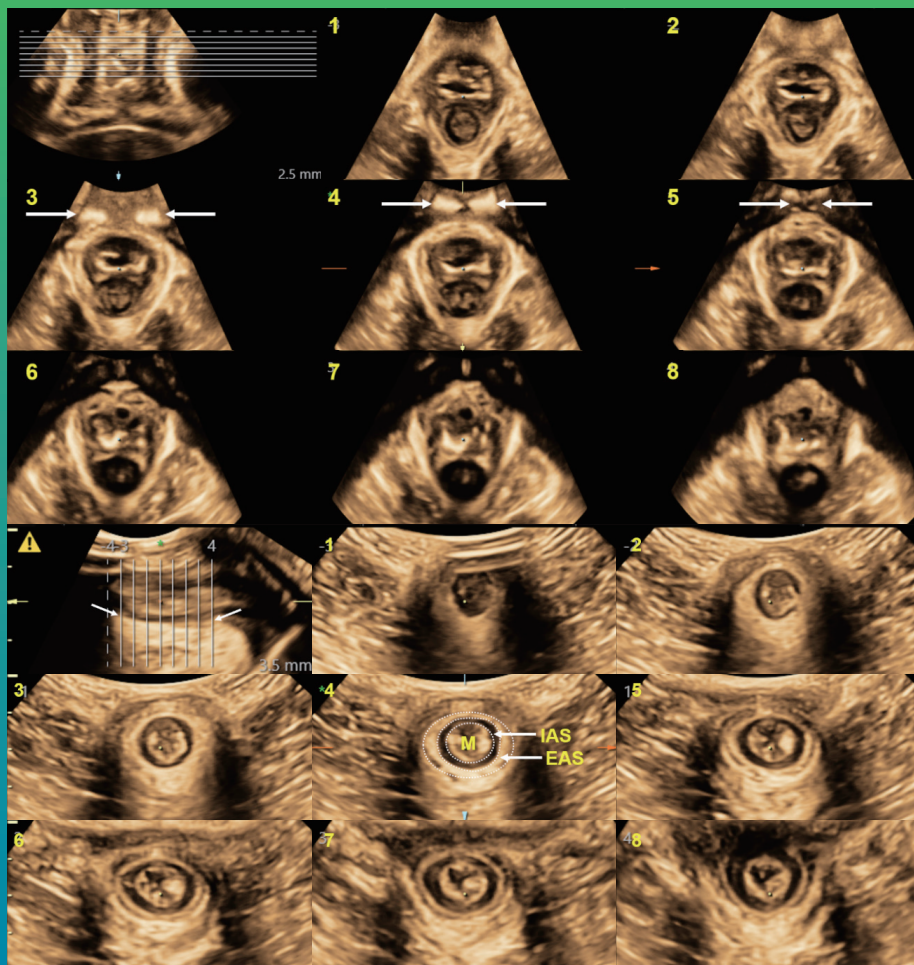
in Diagnosis and Therapy

September, 2023

Volume: 7

Issue: 3

Pages: 217-312



<https://www.AUDT.org>
ISSN: 2576-2508 (Print)
ISSN: 2576-2516 (Online)



CONTENTS

Review Articles

- 217 **Artificial Intelligence-assisted Medical Imaging in Interventional Management of Valvular Heart Disease**
Wenwen Chen, Yuji Xie, Zisang Zhang, Ye Zhu, Yiwei Zhang, Shuangshuang Zhu, Chun Wu, Ziming Zhang, Xin Yang, Manwei Liu, Mingxing Xie, Li Zhang
- 228 **Clinical Application of Robot-assisted Teleultrasound**
Keyan Li, Faqin Lv, Junlai Li
- 235 **Advances and Applications of Transperineal Ultrasound Imaging in Female Pelvic Floor Dysfunction**
Shuangyu Wu, Xinling Zhang
- 248 **Decreased Cerebral Flow Velocities from General Anesthesia are Not Associated with Cerebral Hyperperfusion Syndrome**
Yumei Liu, Yang Hua, Yabing Wang, Nan Zhang, Ting Ma, Yue Zhao, Na Li, Na Lei, Ran Liu
- 254 **Systematic Approaches and Designs for the Optimal Diagnosis and Treatment of Thyroid Nodules via Fine Needle Aspiration**
Jian-Quan Zhang, Lei Yan

Original Research

- 260 **Ultrasound-Guided Attenuation Parameter May Replace B-mode Ultrasound in Diagnosing Nonalcoholic Fatty Liver Disease**
Bo Jiang, Yiman Du, Xiang Fei, Jianing Zhu, Lianhua Zhu, Qiuyang Li, Yukun Luo
- 267 **Localization of Nonpalpable Breast Lumps by Ultrasound Local Coordinates and Skin Inking: A Randomized Controlled Trial**
Leila Bayani, Donya Goodarzi, Reza Mardani, Bita Eslami, Sadaf Alipour
- 272 **Lung Nodule Classification in CT Images Using Improved DenseNet**
Xiuping Men, Vladimir Y. Mariano, Aihua Duan, Xiaoyan Shi
- 279 **Comparison of Sonographic Quantitative Assessment of Splenomegaly in Thalassemia Patients Receiving Whole Blood and Packed Red Cell Transfusions**
Muhammad Arif Afridi, Raham Bacha, Nadeem Ullah, Syed Muhammad Yousaf Farooq, Malik Mairaj Khalid, Imran Khan, Ashfaq Ahmad, Mujahid Sher

- 284 Reproducibility of Ultrasound in Intima-media Thickness Measurement of Common Carotid Artery**

Ziman Chen, Chaoqun Wu

Case Reports

- 288 Contrast-Enhanced Ultrasound in the Detection and Evaluation of Maxillofacial Arteriovenous Malformation: A Case Report**

Chang Liu, Weiwei Shen, Peng Fu, Youchen Xia, Jianxun Ma, Ligang Cui, Shi Tan

- 293 Schistosoma Japonicum Infection of the Ureter and Bladder: A Case Report and Literature Review**

Rongchen Wang, Li Qiu

- 296 Spontaneous Remission of Pediatric Undescended Testis Torsion during Color Doppler Ultrasound Examination**

Huiyong Hu, Hairong Wang, Yunfeng Xu

- 299 Solitary Metastatic Carcinoma of Colon from Renal Cell Carcinoma Misdiagnosed as Primary Colon Carcinoma**

Yemei He, Danni He, Xuankun Liang, Zuofeng Xu

- 302 Imaging Features and Misdiagnosis Analysis of Hyaline Vascular Castleman Disease in the Parotid Region: A Case Report**

Pengyan Zhang, Ling Ren, Yuguang You, Wenjun Xiao

Technical Papers

- 305 The Leap from Digitalization to Intelligentization of Medical Digital Ultrasonic Imaging Workstations**

Yande Zhang, Yanjun Cheng, Yingxin Li, Shengli Li

Comparison of Sonographic Quantitative Assessment of Splenomegaly in Thalassemia Patients Receiving Whole Blood and Packed Red Cell Transfusions

Muhammad Arif Afridi, MS^{a,*}, Raham Bacha, PhD^b, Nadeem Ullah, BS^c, Syed Muhammad Yousaf Farooq, PhD^a, Malik Mairaj Khalid, BS^d, Imran Khan, BS^e, Ashfaq Ahmad^f, Mujahid Sher, PhD^g

^a University Institute of Radiological Sciences & Medical Imaging Technologies (UIRSMIT), The University of Lahore, Pakistan; ^b The University of Lahore, Pakistan; ^c Department of Radiology, Lady Reading Hospital; ^d Bolan Medical College; ^e Department of Radiology, Khyber Medical University; ^f University of Peshawar; ^g Abbottabad University of science and technology Abbottabad

Received October 15, 2022; revision received November 18, 2022; accepted December 26, 2022

Objective: An observational cross-sectional study to assess sonographic splenomegaly quantitatively in thalassemia patients grouped with respect to transfusion given whole blood vs packed red cells.

Methods: A study was conducted among 330 patients equally divided into two groups, undergoing an abdominal ultrasound examination with a transducer frequency ranging from 3-5 MHz during the period December 2021 to August 2022. An independent t-test was applied to compare the splenic volume in thalassemia patients given whole blood transfusions versus packed red cells transfusions, and Cohen's d was used to indicate the standardized difference between two ultrasound splenic volume means.

Results: The mean splenic volume of the patients who received whole blood cells was $320.62 \pm 219.05 \text{ cm}^3$, which is greater than the patients who received packed red cells, whose mean was $60.72 \pm 58.72 \text{ cm}^3$. The splenomegaly was quantitatively assessed in six age groups ranging from 1 to 3 years, 4 to 6 years, 7 to 9 years, 10 to 12 years, 13 to 15 years, and 16-18 years and mean splenic volume in each age group was compared to those receiving whole blood or packed red cells transfusion. there is a statistically significant difference between both transfusion receiving groups, having a larger Cohen's d size effect of 1.62.

Conclusion: Ultrasound is a reliable imaging modality for assessing splenic volume and linear parameters of the spleen with greater splenomegaly in thalassemia patients with whole blood transfusions than those with packed red cells when quantitatively assessed according to relevant age groups. Thalassemia patients should be transfused packed red cells to delay splenomegaly, that should be assessed sonographically.

Key words: Spleen dimensions; Packed red cell; Whole blood; Thalassemia; Ultrasound

Advanced Ultrasound in Diagnosis and Therapy 2023; 03: 279-283

DOI: 10.37015/AUDT.2023.220039

Beta-thalassemia syndromes are a group of hereditary blood disorders characterized by reduced or absent beta globin chain synthesis, resulting in reduced Hemoglobin (Hb) in red blood cells (RBCs), decreased RBCs production, and cause anemia [1]. Clinical presentation of thalassemia major occurs between

* Corresponding author: University Institute of Radiological Sciences & Medical Imaging Technologies (UIRSMIT), The University of Lahore, Pakistan
e-mail: drarifafriidi@gmail.com

6 and 24 months. Affected infants fail to thrive and become progressively pale. Feeding problems, diarrhea, irritability, recurrent bouts of fever, and progressive enlargement of the abdomen caused by spleen and liver enlargement may occur [2]. β -thalassemia remains a significant health problem throughout the world, particularly in Pakistan [3], with blood transfusion and iron chelation being the mainstay of its management. The excessive destruction of RBCs and extra-medullary haematopoiesis cause splenomegaly which increase the transfusion requirement [4]. Splenectomy is indicated in the transfusion-dependent patient when hypersplenism increases blood transfusion requirement and prevents adequate control of body iron with chelating therapy. An enlarged spleen without an associated increase in transfusion requirement is not necessarily an indication for surgery.

The most frequent procedures for diagnosing splenomegaly are ultrasound (US) and computed tomography (CT) scans, which measure a specific spleen dimension and estimate spleen volume. Spleen volume measured in the United States has been demonstrated to be more accurate than spleen volume recorded in CT [5,6]. Several studies have been carried out to investigate the range of healthy spleen dimensions and volume, as well as their relationship to age, gender, and body habitus [7-11].

When evaluating the spleen, ultrasonography is typically employed as the first imaging modality [12]. The spleen is homogenous, somewhat more echogenic than the normal renal cortex, and iso- to slightly hyperechoic when compared to liver parenchyma in the ultrasound. Vascular disease in the splenic hilum can be detected via colour Doppler imaging. Splenic focal lesions are frequently general and mild, manifesting as hypoechoic lesions. As a result, any localized heterogeneity found on sonography should be confirmed using CT or magnetic resonance imaging (MRI) scanning [13].

Material and Methods

The study was conducted during the period December 2021 to August 2022. Consecutive random inclusion of 330 patients in the study. Participating patients were divided into two equal groups. The first group of patients was those patients who received packed cells (erythrocytes), and the second group of patients was those who received whole blood. US was performed, using a transducer of the frequency of 3-5 MHz.

The American Institute of Ultrasound in Medicine (AIUM) guidelines were followed in this study [14]. Formal permission was obtained from the Institutional Ethics Committee to take up this study. After getting permission from the concerned authority, informed consent from the respective individual was taken after

fully explaining the purpose of the research work in their language. Full confidentiality of the patients was maintained.

The grayscale US was used to examine the spleen. All patients were asked to lie down in a supine position or a lateral position to get optimal images. We measured: longitudinal dimension: between the highest superior-medial and the lower inferior-lateral points of the spleen; anteroposterior dimension: between the anterior and posterior surfaces; transverse dimension: between the hilum and the superior-lateral edge of the spleen. Scanning was conducted three times, and the average dimension was taken. The volume of the spleen was calculated using the prolated ellipsoid formula [15,16].

$$V (cm^3) = length (cm) \times width (cm) \times thickness (cm) \times 0.523$$

Spleen measures were obtained, as well as other factors such as the patient's age, gender, and blood type. The frequency and proportion of various spleen measurements were tabulated. The mean, standard deviation, and range were used to describe descriptive data. An independent t-test was applied to compare the splenic volume with whole blood and packed cells in thalassemia patients [17], and Cohen's d was used to indicate the standardized difference between two ultrasound splenic volume means [18]. The study aimed to measure the dimensions of the spleen in thalassemia patients.

Results

In our study we analysed the data on 330 thalassemia patients with splenomegaly. Patients were categorized into two groups with respect to type of transfusion, whole blood transfusions or packed red cells transfusion. There were 165 patients in each group. The patients had a mean age of 9.79 years \pm 5.04 Standard Deviations (SD). There were 161 (48.8%) male and 169 (52.2%) female patients.

In the first group, comprised patients who received packed red cells (erythrocytes). There were 95 male and 75 female patients. The second group comprised patients who received whole blood cells. There were 79 male and 86 female patients.

The mean splenic dimensions and volume were calculated in relevant age groups from 1 to 3years, 4 to 6 years, 7 to 9 years, 10 to 12 years, 13 to 15 years, and 16-18 years in both groups independently.

The mean splenic length, width, depth, and volume in group 1 (packed red cells transfusion) were 7.20 cm (\pm 2.62), 3.74 cm (\pm 1.22), 3.07 (\pm 1.34), and 60.72 cm³ (\pm 58.72) respectively (Table 1). And for group 2 (whole blood transfusion) the respective splenic parameters were

10.02 cm (± 2.17), 7.87 cm (± 2.06), 6.53 (± 1.98), and 320.62 cm³ (± 219.05) (Table 2).

Both transfusion groups with respect to age groups are summarized (Table 3).

An independent-samples t-test was conducted to compare the spleen length for whole blood and packed red cells (Table 4). There were significant differences (t

(316.94) = 10.63, $P < 0.001$) in the scores with the mean score for whole blood ($M = 10.02$, $SD = 2.17$) was higher than and RBC ($M = 7.20$, $SD = 2.62$). The magnitude of the differences in the means (mean difference = 2.18, 95%CI: 2.29 to 3.33) was significant. Hence, we have enough evidence to reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1).

Table 1 Mean splenic length, width, depth, and volume for packed red blood cells (RBCs) transfusion

Years	Frequency	Male	Female	Length (cm)	Width (cm)	Depth (cm)	Volume (cm ³)
1-3	36	22	14	3.84	2.21	1.50	7.22
4-6	30	15	15	6.16	3.46	1.98	22.90
7-9	31	14	17	6.48	3.24	2.95	32.47
10-12	22	10	12	7.74	3.87	3.52	57.45
13-15	28	15	13	10.34	5.17	4.70	131.03
16-18	18	14	4	11.38	5.69	5.17	174.55
Total	165	90	75	7.20 \pm 2.61	3.74 \pm 1.22	3.07 \pm 1.34	60.72 \pm 58.72

Table 2 Mean splenic length, width, depth, and volume for whole blood cells transfusion

Years	Frequency	Male	Female	Length (cm)	Width (cm)	Depth (cm)	Volume (cm ³)
1-3	11	7	4	5.79	4.22	3.55	52.59
4-6	23	10	13	8.10	6.04	4.66	119.29
7-9	30	14	16	9.17	6.22	4.83	131.95
10-12	24	8	16	11.48	9.27	7.88	436.96
13-15	41	18	23	11.50	9.29	7.90	440.66
16-18	36	22	14	12.74	10.53	9.14	639.94
Total	165	79	86	10.2 \pm 2.17	7.87 \pm 2.06	6.53 \pm 1.98	320.62 \pm 219.05

An independent-samples t-test was conducted to compare spleen width for whole blood and packed red cells with significant differences (t (328) = 22.15, $P < 0.001$) in the scores with the mean shown in Table 4. The magnitude of the differences in the means (mean difference = 4.14, 95%CI: 3.77 to 4.50) was statistically significant.

An independent-samples t-test was also conducted to compare the spleen depth for whole blood and packed red cells and there were significant differences (t (328) = 18.60, $P < 0.001$) in the scores (Table 5). The magnitude of the differences in the means (mean difference = 3.46, 95%CI: -3.09 to 3.83) was statistically significant, to reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1).

The spleen volume for whole blood and packed red cells were compared by independent-samples t-test with significant differences (t (328) = 14.72, $P < 0.001$) in the scores. The magnitude of the differences in the means (mean difference = 259.90, 95%CI: 225.16 to 294.63) was significant. Hence, we have enough evidence to reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1).

Cohen's d was used to indicate the standardized difference between two ultrasound splenic volume means. Fig. 1 shows that there was a significant difference between splenic volume in patients with thalassemia receiving whole blood and red blood cells. In our study, the Cohen's d size effect was large [18], which was 1.62.

Table 3 Comparison of mean between whole blood and packed cells wrt age groups

Blood Group	Age groups	Mean Volume (cm ³)	Std. Deviation
Whole Blood	1-3years	52.59	31.86
	4-6years	119.29	16.62
	7-9years	131.95	11.85
	10-12years	436.96	48.37
	13-15years	440.66	52.66
	16-18years	639.94	77.73
	Total	320.62	219.05
Red Blood Cells	1-3years	7.22	3.83
	4-6years	22.90	6.69
	7-9years	32.47	4.94
	10-12years	57.45	22.63
	13-15years	131.03	13.16
	16-18years	174.55	16.00
	Total	60.72	58.72

Table 4 An independent samples t-test to compare the spleen dimensions for whole blood and red blood cells

Spleen Dimensions	Variances	Mean	SD	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
				F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Length (cm)	Equal variances assumed	10.02	2.17	2.87	0.09	10.63	328.00	0.00	2.81	0.26	2.29	3.33
	Equal variances not assumed	7.20	2.62			10.63	316.94	0.00	2.81	0.26	2.29	3.33
Width (cm)	Equal variances assumed	7.87	2.06	102.27	0.00	22.15	328.00	0.00	4.14	0.19	3.77	4.50
	Equal variances not assumed	3.74	1.22			22.15	266.44	0.00	4.14	0.19	3.77	4.50
Depth (cm)	Equal variances assumed	6.53	1.98	72.46	0.00	18.60	328.00	0.00	3.46	0.19	3.09	3.83
	Equal variances not assumed	3.07	1.34			18.60	288.24	0.00	3.46	0.19	3.09	3.83
Volume (cm ³)	Equal variances assumed	320.62	219.05	402.77	0.00	14.72	328.00	0.00	259.90	17.66	225.16	294.63
	Equal variances not assumed	60.72	58.72			14.72	187.45	0.00	259.90	17.66	225.07	294.73

Discussion

Organ volume measurement plays an important role in the clinical diagnosis and follow-up of diseases. Many diseases present changes in the size and morphology of the organs. Therefore, determining normal parameters of the organs bears great importance in terms of accurate evaluation of pathological changes [19].

Several research studies have aimed to define the standard size of the spleen, using different imaging techniques such as computed tomography, magnetic resonance imaging, and ultrasonography [20-22]. Volumetric measures can be acquired most precisely using computed tomography or magnetic resonance imaging [20]. Nonetheless, regular computed tomography for the diagnosis and serial follow-up of patients with suspected splenic enlargement is difficult to justify in our context due to the radiation exposure (particularly

in paediatrics or teenage population) and the high-cost price. Magnetic resonance imaging is further hindered by high costs and limited availability in many parts of the world, particularly in underdeveloped nations. Ultrasonography's economic and valuable non-invasive role in evaluating the spleen dimensions can demonstrate the existence and structure of splenic masses, disruption of splenic outline (texture), progressive changes in masses, and the size of the spleen.

Conclusion

The purpose of this study was to compare the effects of blood transfusion on the spleen of thalassemia patients. From the statistical results, there was a morphological relationship between the transfusion of packed cells and whole blood transfusion; the mean splenic dimensions obtained across the two groups were different, where

the patients who received whole blood, their spleen was observed to be larger than the patients who received packed cells on Ultrasound. When we compared packed cell receivers to those administered with whole blood, there was nearly a four folds difference. Therefore, based on our results it may be recommended that the administration of packed cells is better than whole blood receivers.

Recommendations:

To avoid thalassemia, proper screening should be done before marriage. Thalassemia is diagnosed by blood tests such as the complete blood count (CBC) test, which evaluates the quantity of hemoglobin in a blood sample, and specific hemoglobin tests, which determine the kind of hemoglobin in a blood sample. The severity of thalassemia (moderate and severe) is frequently identified in infancy, because signs and symptoms, such as severe anemia, commonly appear during the first two years of life.

Patients with thalassemia are continuously transfused with either packed cells or whole blood, which affects the spleen. Sometimes packed cells are not available in all the hospitals in developing countries. The spleen dimensions were sonographically observed in the patients receiving packed cells and whole blood. A statistically significant variation was found in the spleen dimension in the two groups.

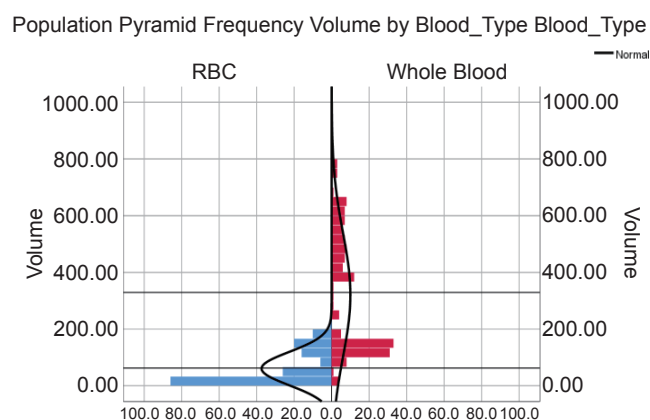


Figure 1 Graph indicates that a larger Cohen's d size effect between two means.

Conflict of Interest

The authors declare no conflicts of interest.

References

[1] Tari K, Valizadeh Ardalan P, Abbaszadehdibavar M, Atashi A, Jalili A, Gheidishahran M. Thalassemia an update: molecular basis, clinical features and treatment. *International journal of biomedicine and*

public health 2018;1:48-58.

- [2] Origa R. β -Thalassemia. *Genetics in Medicine* 2017;19:609-619.
- [3] Akhtar S, Nasir JA, Hinde A. The prevalence of hepatitis C virus infection in β -thalassemia patients in Pakistan: a systematic review and meta-analysis. *BMC Public Health* 2020;20:587.
- [4] Merchant RH, Shah AR, Ahmad J, Karnik A, Rai N. Post splenectomy outcome in β -thalassemia. *The Indian Journal of Pediatrics* 2015;82:1097-1100.
- [5] Olson AP, Trappey B, Wagner M, Newman M, Nixon LJ, Schnobrich D. Point-of-care ultrasonography improves the diagnosis of splenomegaly in hospitalized patients. *Critical ultrasound journal* 2015;7:1-4.
- [6] Similuoto TM, Tikkaoski TA, Lähde ST, Päivänsalo MJ, Koivisto MJ. Ultrasound or CT in splenic diseases? *Acta Radiol* 1994;35:597-605.
- [7] Yetter EM, Acosta KB, Olson MC, Blundell K. Estimating splenic volume: sonographic measurements correlated with helical CT determination. *AJR Am J Roentgenol* 2003;181:1615-1620.
- [8] Saboo S, Krajewski K, O'regan K, Giardino A, Brown J, Ramaiya N, et al. Spleen in haematological malignancies: spectrum of imaging findings. *Br J Radiol* 2012;85:81-92.
- [9] Lamb PM, Lund A, Kanagasabay RR, Martin A, Webb JA, Reznick RH. Spleen size: how well do linear ultrasound measurements correlate with three-dimensional CT volume assessments? *Br J Radiol* 2002;75:573-577.
- [10] Arkles LB, Gill GD, Molan MP. A palpable spleen is not necessarily enlarged or pathological. *Med J Aust* 1986;145:15-17.
- [11] Schloesser LL. The diagnostic significance of splenomegaly. *Am J Med Sci* 1963;245:84-90.
- [12] Catalano O, Sandomenico F, Vallone P, D'Errico AG, Siani A. Contrast-enhanced sonography of the spleen. *Semin Ultrasound CT MR* 2006;27:426-433.
- [13] Balan P. Ultrasonography, computed tomography and magnetic resonance imaging in the assessment of pelvic pathology. *Eur J Radiol* 2006;58:147-155.
- [14] Bacha R, Manzoor I, Gilani SA. Sonographic presentation of rice bodies in subacromial-subdeltoid chronic bursitis. *Ultrasound J* 2019;11:16.
- [15] Hertzberg BS, Middleton WD. *Ultrasound: the requisites*: Elsevier Health Sciences; 2015.
- [16] Sağıroğlu A, Acer N, Ertekin T, Kurtoğlu E, Coşkun A, Yıldırım A, et al. Estimation of spleen volume and surface area of the newborns' cadaveric spleen using stereological methods. *Folia Morphol (Warsz)* 2014;73:183-192.
- [17] Gerald B. A brief review of independent, dependent and one sample t-test. *International Journal of Applied Mathematics and Theoretical Physics* 2018;4:50-54.
- [18] McLeod SA. What does effect size tell you. *Simply psychology* 2019.
- [19] Dogan TH, Basak M, Karatag O, Degirmenci H, Ozkurt H. Evaluation of liver, spleen and kidney sizes by ultrasonography in normal children between the age of 0-14. *COCUK SAGLIGI VE HASTALIKARI DERGISI* 2004;47:107-113.
- [20] Ehimwenma O, Tagbo MT. Determination of normal dimension of the spleen by ultrasound in an endemic tropical environment. *Niger Med J* 2011;52:198-203.
- [21] Kebede T, Admassie D. Spleen length in childhood with ultrasound normal based on age at Tikur Anbessa Hospital. *Ethiop Med J* 2009;47:49-53.
- [22] Son JH, Lee SS, Lee Y, Kang BK, Sung YS, Jo S, et al. Assessment of liver fibrosis severity using computed tomography-based liver and spleen volumetric indices in patients with chronic liver disease. *Eur Radiol* 2020;30:3486-3496.