Cirrhotic Ascites management via procalcitonin level and a new approach B-mode gray-scale histogram

LIVER

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ABSTRACT

Background/Aims: To determine the role of serum procalcitonin levels and ascites/subcutaneous echogenicity ratio (ASER) in predicting ascites infection in hospitalized cirrhotic patients.

Materials and Methods: A total of 50 patients hospitalized because of cirrhosis-related ascites were included in this study. In these patients, 44% of ascites were infected (peritonitis), whereas 56% of ascites were sterile. These two groups were compared in terms of procalcitonin levels and ASER for predicting ascites infection. Receiver operating characteristic (ROC) curves were used to evaluate the diagnostic performance of ASER, and the predicting outcome of ASER was compared with procalcitonin levels.

Results: The ASER values of the patients with the diagnosis of infected ascites were significantly higher than in those with the diagnosis of sterile ascites (p<0.001). ROC analysis was performed to determine the diagnostic ASER value for infected ascites. An ASER greater than 0.0019 determined peritonitis with 95.5% sensitivity and 100% specificity. A procalcitonin level greater than 0.05 determined peritonitis with 86.4% sensitivity and 75% specificity. Using ROC analysis, an ASER greater than 0.0019 [area under curve (AUC): 0.974, 95% confidence interval (CI) (0.884–0.999, p<0.001)] was a significantly better diagnostic marker than a procalcitonin level >0.5 mg/dL [AUC: 0.860, 95% CI (0.884–0.999, p<0.001) (p<0.045)].

Conclusion: According to our findings, the determination of ASER and serum procalcitonin levels seems to provide satisfactory diagnostic accuracy in differentiating ascites infections in hospitalized cirrhotic patients. ASER values significantly differentiate ascites infections better than procalcitonin levels.

Keywords: Ascites/subcutaneous echogenicity ratio (ASER), procalcitonin, ascitic fluid infection, cirrhosis, spontaneous bacterial peritonitis

INTRODUCTION

Ascites development is a poor prognostic factor of cirrhosis and also increases the risk of developing hyponatremia, spontaneous bacterial peritonitis (SBP), and hepatorenal syndrome (1); SBP is the leading complication for hospital admission (2).

There is an increased rate of mortality, hepatic encephalopathy, and hepatorenal syndrome risk in SBP patients; early diagnosis and rapid management are the key aspects of this complication. Empirical antibiotic treatment is indicated for an ascitic fluid polymorphonucler leucocyte (PMNL) count >250/mm³. However, additional supporting systemic infection markers and an ascites-specific radiological examination are required because of low ascitic fluid culture positivity (approximately 30%), delay in culture results, iatrogenic SBP risk after diagnostic paracentesis, difficulty of paracentesis procedure, and an ascites differential diagnosis other than cirrhosis.

Procalcitonin, a calcitonin precursor, is a glycopeptide containing 116 aminoacids and is produced by the C cells of the thyroid gland. In the healthy population, pro-

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calcitonin levels are very low (<0.15 ng/mL) or undetectable. Sepsis and serious invasive infections are the leading causes of increased procalcitonin levels and are rapidly decreased by appropriate antibiotic treatment. In contrast, viral infections, noninfectious inflammations, and malignant diseases have low or undetectable procalcitonin levels (3,4). Recent studies have shown that procalcitonin is a better diagnostic marker than white blood cell (WBC) count or C-reactive protein (CRP) level for the diagnosis of infection (1). In 2014, a systemic review indicated that procalcitonin determination is a relatively sensitive and specific test for the diagnosis of bacterial peritonitis (5).

Currently, ultrasound (US) has a limited role in the management of ascites. Generally, it is used to guide paracentesis and to detect small amounts of ascites that are undetectable during clinical examination (4).

We can classify ascites as anechoic simple, exudative, debris-laden, and septated according to the sonographic image (6). However, these described characteristics are subjective (qualitative) auxillary data, and they have limited efficacy in the discrimination between infected ascites and sterile ascites (6).

Gray-scale histogram analysis provides quantitative information about the echogenicity of the image to be analyzed. It can provide information about the echogenicity value of ascitic fluid, which cannot be discerned by the naked eye (6).

According to these data, we investigated the hypothesis of using ascites/subcutaneous echogenicity ratio (ASER) for differentiating infected ascites from sterile ascites and compared ASER with procalcitonin levels in terms of evaluating the two markers for diagnosing peritonitis.

Thus, this article is the first research paper using a gray-scale histogram for ascitic fluid infection diagnosis. We aimed to compare ASER with procalcitonin levels, because procalcitonin has been an accepted diagnostic marker for cirrhotic ascites infections.

MATERIALS AND METHODS

Study population
Ninety-six hospitalized cirrhotic patients complicated with ascites were evaluated between June 2014 and January 2015 at the Antalya Training and Research Hospital Gastroenterology Clinic. Only cirrhotic patients were included in the study population, and patients with a concurrent secondary infection, malignancy, and serum ascites albumin gradient (SAAG) <1.1 were excluded from the study population. A total of 30 patients with a concurrent secondary infection and 16 patients with malignant diseases were excluded from the study population. All ASER values were evaluated in a single-blinded fashion by the same radiologist and were correlated by a second radiologist. After the exclusion criteria were applied to the study population, a total of 50 patients were included, and procalcitonin levels and ASER values

were compared in this prospective and cross-sectional study. A written informed consent was obtained from all subjects. The study was approved by the Clinical Research and Ethics Committee of Antalya Training and Research Hospital.

Paracentesis and culture techniques
After local anesthesia with lidocaine was administered using a 17-G needle, diagnostic paracentesis was performed at the bedside using a sterile method with a 23-G needle attached to a 20-cc syringe. Immediately after the paracentesis needle and attached syringe were withdrawn from the abdomen, the "skin" needle was removed and replaced with a sterile needle to minimize the risk of skin flora growing in the cultures. Next, the ascitic fluid was aspirated and collected into ethylenediaminetetraacetic acid tubes and analyzed within 3 h of aspiration. Ascitic fluid was then centrifuged in the laboratory for 3 min and analyzed for total protein and total and differential leukocyte counts. A smear was prepared and stained with Giemsa. Peritoneal fluid collected from the patients was cultured using two methods. In the first method, 20 mL of peritoneal fluid was inoculated in aerobic blood culture bottles. These bottles were then placed in an automated BacT/Alert 3D (BioMerieux; Durham, NC, USA) culture system. Bottle incubation and subsequent testing were performed according to the manufacturer's protocol. In the second method, the remaining sample was cultured using conventional culture methods (i.e., inoculation using blood agar, MacConkey agar, and thioglycollate broth). The conventional agar and broth media were incubated at 35°C for up to 3 days before being discarded as negative. Bacterial identification and antimicrobial susceptibility testing were performed using standard procedures (6).

Ultrasound histogram analysis
All radiological examinations were performed by the same radiologist and correlated by another radiologist. The radiologists had no information about the nature of the patients' ascites. US images were obtained from patients referred to our clinic with diagnosis of ascites using an US device (Hi-Vision Prerius; Hitachi medical systems, Tokyo, Japan). All subjects were examined in the supine position with a 7.5 MHz linear-array transducer. All US images were analyzed using gray-scale US and gray-scale histogram methods.

The scans of the right upper abdominal quadrant were obtained using a subcostal approach. Gray-scale US images were recorded in the database.

Image J software (National Institutes of Health; Bethesda, Maryland, USA) was used for the gray-scale histogram examinations of electronically recorded US images. Echogenicity values were measured as 0–256 (0: black, 256: white) using histogram analysis in a sampling area (diameter, 5–10 mm).

Prior US images obtained in the subcostal oblique view were measured at the subcutaneous level. The quantitative mea-
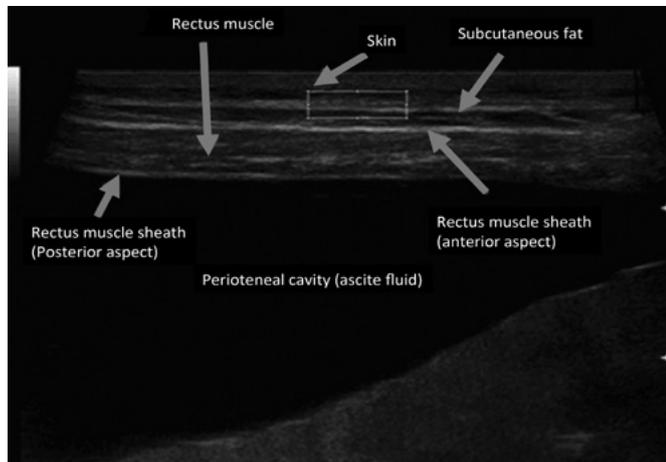
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Figure 1. Ultrasound anatomy of the subcutaneous tissue and contiguous structures measured with gray-scale histogram.

surements of ascitic fluid were made at the subcutaneous level and midpoint of its deepest level.

Subcutaneous measurements were performed using US from the hypoechoic fatty tissue between the hyperechoic skin layer and hyperechoic anterior aspect of the rectus abdominis muscle sheath. We obtained reference measurements from the subcutaneous tissue to minimize the probable disparity of the gray-scale echogenicity values among the patients (Figure 1).

Measurements were repeated three times, and an average of three measurements was estimated. The gray-scale histogram data we retrieved from the level of ascitic fluid and subcutaneous level using the Image J software were compared and the ASER was obtained. Gray-scale histogram echogenicity values were correlated with histopathological values (Figure 2 a-d).

The measurements of the ascitic fluid were not performed from the areas demonstrating septas, debris, and ultrasonographic artifacts.

Classification of patients according to ascitic fluid infection
The presence of ascitic fluid infection was determined on the basis of WBC/PMNL counts and culture positivity in ascitic fluid. Accordingly, patients were classified into two groups, one as ascitic fluid infection (WBC count ≥500/mm^3 and PMNL >250/mm^3 in ascitic fluid) and the other as sterile ascites (WBC count <500/mm^3 and PMNL count <250/mm^3 in ascitic fluid and with a negative culture).

The etiology of cirrhosis was recorded in cirrhotic patients with respect to hepatitis B virus (HBV), hepatitis C virus (HCV), alcoholic, cryptogenic, and autoimmune cirrhoses. The severity of cirrhosis was classified on the basis of the Child-Pugh criteria (7). All cirrhotic patients were evaluated for the presence of hepatocellular carcinoma using US, in addition to obtaining serum alpha-feto protein (AFP) levels.

Assessments
Data on ascitic fluid analysis, including WBC count (cells/mm^3); albumin, protein, glucose, and lactate dehydrogenase (LDH) levels in ascitic fluid; blood biochemistry, including serum levels of albumin, CRP, and AFP; sedimentation rate; SAAG; and serum procalcitonin levels (ng/mL), were obtained from each patient during the investigation period.

The procalcitonin level of serum samples, which were obtained at the same time as the ascitic samples, were measured via a Cobas immunoassay analyzer (Roche Diagnostics; Mannheim, Germany) using an electrochemiluminescence immunoassay method (Brahms Diagnostica; Berlin, Germany) with a detection limit of 0.5 ng/mL and a coefficient of variability of 8%.

The peritonitis and sterile ascites groups were compared in terms of procalcitonin levels and ASER to determine the value of procalcitonin levels and ASER for predicting ascitic fluid infection. Cut-off values for procalcitonin levels (ng/mL) and ASER to exclude the diagnosis of bacteremia were calculated for each group. ROC curves were plotted for ASER for the peritonitis group with procalcitonin levels to evaluate their abilities to identify ascitic fluid infection in the study population. Outcome predictions of ASER were compared with procalcitonin levels by comparing their area under curve (AUC).

Statistical analyses
Descriptive statistics were presented with frequency, percentage, mean, and standard deviation values. The relation between categorical values was analyzed with the Fisher's exact test or Pearson chi-square test. The normality assumptions of the analysis of the two-group measurement differences were controlled by the Shapiro–Wilk test. The Mann–Whitney U test was used for abnormal distribution control. To evaluate for normal distribution, a two-independent-sample t-test was used. To distinguish infected patients from sterile patients according to specific measurements and to determine the cut-off point, ROC analysis was performed.

AUC, cut-off points, sensitivity, specifity, positive predictive value, and negative predictive value were presented for all results. P values <0.05 were considered statitistically significant. Analyses were performed using the Statistical Package for the Social Sciences (SPSS Inc.; Chicago, IL, USA) 22.0 software.

RESULTS

Patient demographics and classification according to the classification of ascites
Among the 50 patients (age: 67.08±14.14; 52% were males and 48% were females) hospitalized with ascites and cirrhosis, HBV-related (32%), HCV-related (24%), alcoholic (24%), cryptogenic (16%), and autoimmune cirrhoses (4%) were the most common cirrhosis types (Table 1).
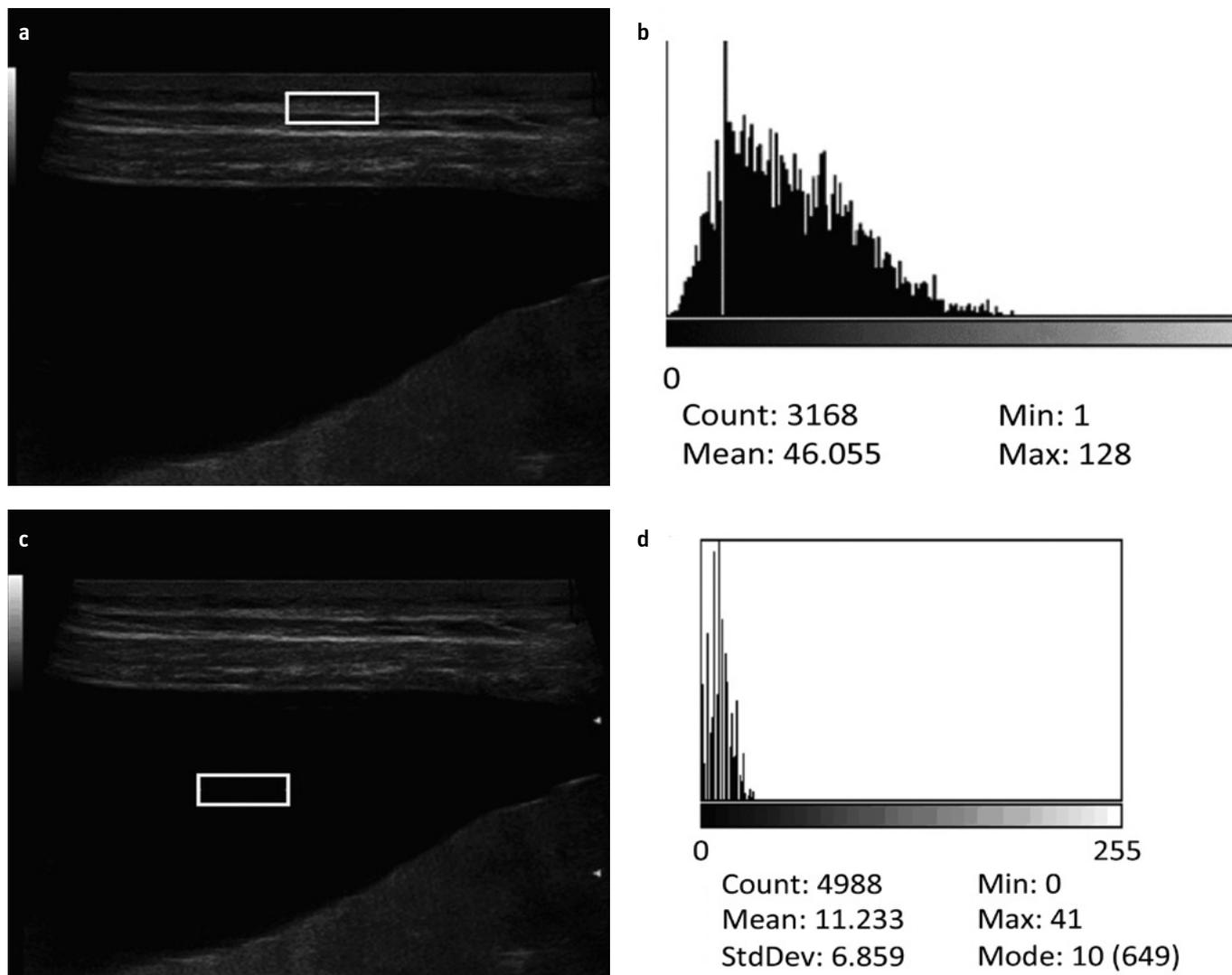
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Figure 2. a-d. Measurement performed from the subcutaneous fatty tissue (a), gray-scale histogram values of the subcutaneous fatty tissue (b), measurement performed from ascitic fluid (c), gray-scale histogram values of ascitic fluid (d).

Table 1. Patient demographics

Gender	Female	24	48.0%
	Male	26	52.0%
Mean age (SD)		67.08 (14.14)	
Infected/sterile	Sterile	28	56.0%
	Infected	22	44.0%
Infected group	SBP	9	40.9%
	Neutrocytic	13	59.1%
Cirrhosis etiology	HBV	16	32.0%
	HCV	12	24.0%
	Alcoholic	12	24.0%
	Cryptogenic	8	16.0%
	Autoimmune	2	4.0%
Culture	Negative	41	82.0%
	Positive	9	18.0%

SD: standard deviation: SBP: spontaneous bacterial peritonitis; HBV: hepatitis B virus; HCV: hepatitis C virus

Patients were divided into two groups: group 1: infected ascites (peritonitis group) and group 2: sterile ascites. Group 1 consisted of 22 (44%) patients, and group 2 consisted of 28 (56%) patients (Table 1). No significant gender or age difference was observed between the groups (Table 2).

Ascitic fluid analysis

Ascitic fluid analysis revealed a WBC count (cells/mm^3) of 1390±1073.4 in the peritonitis group and that of 228.5±111.7 in the sterile ascites group; this difference was statistically significant (p<0.001) (Table 2).

The SAAG was 1.90±0.31 in the peritonitis group and 2.15±0.68 in the sterile ascites group (Table 2). A total of 56% of ascites were sterile, 44% of ascites were infected (peritonitis), and 40% of peritonitis cases were culture positive. The most frequently found pathogen was *Escherichia coli* (5 of 9 cases), followed by *Staphylococcus aureus* (2 of 9 cases) and *Klebsiella pneumonia* and pneumococcus (1 of 9 cases) (Table 2).

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Table 2. Ascitic fluid analysis with respect to classification of ascites

		Infected/sterile				
		Sterile		**Infected**		**p**
Gender (n, %)	Female	15	53.6%	9	40.9%	0.374$^\epsilon$
	Male	13	46.4%	13	59.1%	
Mean age (SD)		68.32 (13.05)		65.50 (15.57)		0.487$^+$
Mean CRP level (SD)		47.93 (39.28)		43.91 (34.43)		0.853$^+$
Mean procalcitonin level (SD)		0.55 (0.28)		1.56 (1.21)		<0.001$^+$
Procalcitonin group (n, %)	≤0.50	21	75.0%	3	13.6%	<0.001$^\epsilon$
	>0.50	7	25.0%	19	86.4%	
ASER mean (SD)		5.33×10^{-4} (5.15×10^{-4})		0.125 (0.015)		<0.001$^+$
ASER group (n, %)	≤0.0019	27	96.4%	1	4.50%	<0.001$^\epsilon$
	>0.0019	1	3.6%	21	0.96	
Mean Child-Pugh score (SD)		8.07 (1.51)		9.50 (1.68)		0.003$^\#$
Mean AFP level (SD)		33.40 (17.04)		59.22 (19.68)		0.162$^+$
Mean SAAG (SD)		2.15 (0.68)		1.90 (0.31)		0.147$^+$
Mean serum albumin level (SD)		3.19 (0.63)		3.12 (0.57)		0.462$^+$
Mean ascites albumin level (SD)		1.04 (0.63)		1.22 (0.45)		0.262$^\#$
Mean ascites total protein (SD)		538.96 (197.75)		546.64 (231.58)		0.883$^+$
Mean ascites WBC count (SD)		228.57 (111.74)		1390.91 (1073.45)		<0.001$^+$

SD: standard deviation; CRP: C-reactive protein; ASER: ascites/subcutaneous tissue echogenicity ratio; AFP: alpha-feto protein; SAAG: serum ascites albumin gradient; WBC: white blood cell
$^\epsilon$Pearson chi-square Test; $^\&$Fisher's Exact Test; $^+$Mann–Whitney U Test; $^\#$Two-independent-sample t-test

Table 3. Estimates of diagnostic test for procalcitonin and measurements at the level of ascites and subcutaneous tissue for the discrimination between infected and sterile ascites

	AUC	**Cut-off value**	**Sensitivity (%)**	**Specificity (%)**	**+PV**	**−PV**	**p**
Procalcitonin	0.860, 95% CI (0.732–0.942) (p<0.001)	>0.5	86.4	75	73.1	87.5	0.045*
ASER	0.974, 95% CI (0.884–0.999) (p<0.001)	>0.0019	95.5	100	100	96.6	

AUC: area under curve; PV: predictive value; CI: confidence interval; ASER: ascites/subcutaneous tissue echogenicity ratio
*p<0.05 significant

Sex, age, CRP and AFP levels, SAAG, and ascites total protein did not show a significant difference between the infected and sterile ascites groups (Table 2).

Procalcitonin levels and ASER with respect to the classification of ascites

Serum procalcitonin levels were determined to be significantly higher in patients with infected ascitic fluid than in patients with sterile ascites (1.56±1.21 vs. 0.55±0.28, p<0.001) (Table 3). Additionally, ASER values were significantly higher in patients with infected ascitic fluid than in patients with sterile ascites (0.125±0.015 vs. 5.33×10^{-4}±5.15×10^{-4}, p<0.001) (Table 2).

Comparison of procalcitonin levels and ASER

The serum procalcitonin levels were found to be significantly higher in the peritonitis group. ROC analysis was performed to determine the ideal cut-off value for diagnosis. The cut-off value for procalcitonin was 0.5 ng/mL with a sensitivity of 86.4%

and specificity of 75%. A serum procalcitonin level of <0.5 ng/mL was determined to accurately rule out the diagnosis of bacterial infection (Table 3). In addition, the ASER level of >0.0019 for the determination of ascites infection was a good diagnostic test with a sensitivity of 95.5% and a specifity of 100%. AUC, sensitivity, and specifity results of all tests were very close to 80% or higher than 80%, indicating higher true positive and true negative results (Table 3).

Using ROC analysis, an ASER greater than 0.0019 [AUC: 0.974, 95% confidence interval (CI) (0.884–0.999, p<0.001)] was a significantly better diagnostic marker than a procalcitonin level of >0.5 mg/dL [AUC: 0.860, 95% CI (0.884–0.999, p<0.001) (p<0.045)] (Table 3 and Figure 3).

DISCUSSION

Appropriate diagnostic studies and prompt administration of therapy are the mainstays of the successful management of

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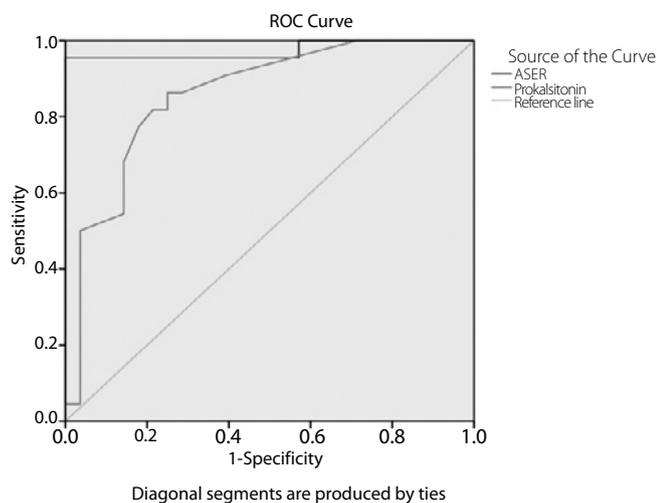
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Figure 3. ROC curve of procalcitonin and ascites/subcutaneous histogram ratio of infected and sterile ascites.
ROC: receiver operating characteristic; ASER: ascites/subcutaneous tissue echogenicity ratio

ascites because of frequent hospitalization requiring extremely complex and labor-intensive care as well as appreciable morbidity and mortality (8).

Accordingly, in contrast to other markers found to be indicative of SBP, including ascitic pH, lactate dehydrogenase, and lactate levels, none of these markers have been considered sufficenlty diagnositc for SBP (1).

In terms of the value of procalcitonin in predicting infection, studies conducted in cirrhotic patients with bacterial peritonitis yielded conflicting results. In a study by Viallon et al. (9), the serum levels of procalcitonin were reported to be one of the best markers for the diagnosis of SBP, with a cut-off value of 0.75 ng/mL, sensitivity of 95%, and specificity of 98%. In another study by Cekin et al. (1), it was demonstrated that for the SBP group, the cut-off value for procalcitonin level was 0.61 ng/mL with a sensitivity of 100% and a specificity of 92%. A serum procalcitonin level of <0.61 ng/mL (AUC: 0.981, 95% CI: 0.000–1.000, p<0.001) was determined to accurately rule out the diagnosis of ascites infection. In this study, we demonstrated that high procalcitonin levels should be considered in combination with a high PMNL count in the differential diagnosis of patients with ascites. Additionally, Lippi et al. (10) developed a tentative algorithm for the efficient diagnosis of SBP; procalcitonin was at the first step of this algorithm. Cai et al. (11) showed that serum procalcitonin levels alone or in combination with WBC/platelet measurements seem to provide a satisfactory early diagnostic biomarker in decompensated cirrhosis patients with infections, particularly in patients with SBP. In a systemic review and meta-analysis in 2014, Yang et al. (14) evaluated 18 studies (including our study by Cekin et al. (1) and 1,827 patients), and their results indicated that procalcitonin determination is a relatively sensitive and specific test for the diagnosis of bacterial peritonitis (5). Spahr et al. (12) concluded, based on their

findings in a series of 10 patients with bacterial peritonitis and 10 with sterile ascites, that procalcitonin levels were inaccurate in these patients; however, this study was limited by a small sample size. Schwabl et al. (13) could not find a correlation between the parameters of mortality risk in patients with SBP and procalcitonin levels; however, only the first-day procalcitonin levels were measured, and procalcitonin response to antibiotic treatment was not measured.

Our study demonstrated that in cirrhotic patients, similar to findings of our previous study by Cekin et al. (1) and other studies by Viallon et al. (9), Lippi et al. (10), Cai et al. (11), Yang et al. (14) and in contrast to the studies by Spahr et al. (12) and Schwabl et al. (13), procalcitonin levels were significantly high in the infected ascites group than in the sterile ascites group (1.56±1.21 vs. 0.55±0.28, p<0.001) (Table 3).

We also performed gray-scale histogram analysis of peritoneal fluid using an ultrasonographic method, investigated the efficacy of this analytical method for the discrimination between sterile and infected ascites, and compared ASER's diagnostic power with procalcitonin levels.

Gray-scale histogram analysis provides quantitative information about the echogenicity of the lesion or fluid. In the US evaluation of ascites, the terms of anechoic or hypoechoic have been frequently used; however, these terms encompass a large spectrum of conditions and do not provide detailed information about the echogenicity of the lesion. US images have very different gray-scale histogram values. The histogram illustrates how the pixels in an image are distributed by graphing the number of pixels at each color intensity level. With gray-scale histogram analysis, the echogenicity values of images can be numerically expressed (15). It has been demonstrated that using numerical values of echogenicities of lesions can aid in the differential diagnosis of various pathologies (15).

Most of the studies that aim at differentiation between cases with infected and sterile ascites using radiological methods generally investigate an association between gallbladder wall thickness and ascites infection. Saverymuttu et al. (16) reported that gallbladder wall thickness greater than 3 mm developed in 89% of the patients diagnosed with infected ascites, whereas its thickness was less than 3 mm in 94% of those diagnosed with sterile ascites. In radiological studies where computed tomography (CT) data were obtained from patients with ascites, the density of ascitic fluid was reported to be higher in patients with infected ascites. Risson et al. (17) retrospectively reviewed the CT images of 102 patients (51 infected and 51 sterile ascites) with the diagnosis of ascites, and they revealed the presence of ascitic fluid in the omental bursa, peritoneal thickening, enhanced contrast uptake, and loss of intestinal mobility. Similar to our study, they detected a significant increase in the density of the ascitic fluid, which they attributed to higher leucocyte concentrations in the infected ascites group. Schwerk et al. (18)

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evaluated abdominal fluid collections to distinguish between sterile collections and abscess. Results from both gray-scale US and confirmatory aspiration provided detailed diagnostic information about abdominal fluid collections.

In our study, ASER values that we used in the gray-scale histogram analysis can be utilized as an adjunct to US examination in the differentiation of sterile ascites. We have observed that using gray-scale histogram analysis, discrimination between sterile and infected ascites can be obtained with great precision.

ASER values were significantly higher in patients with infected ascitic fluid than in patients with sterile ascites (0.125 ± 0.015 vs. $5.33 \times 10^{-4} \pm 5.15 \times 10^{-4}$, $p<0.001$). Using ROC analysis, an ASER greater than 0.0019 [AUC: 0.974, 95% CI (0.884–0.999, $p<0.001$)] was a significantly good diagnostic marker for infected ascites. Additionally, ASER was a significantly better diagnostic marker than a procalcitonin level >0.5 mg/dL [AUC: 0.860, 95% CI (0.884–0.999 $p<0.001$) ($p<0.045$)]. The diagnostic value of ASER was very high, and it can be employed as an auxillary sonographic parameter. While undertaking background research, we did not find studies on the impact of gray-scale histogram on the differentiation between benign and malignant ascites.

Our study has some limitations. The employed gray-scale histogram analysis, changes in fluid and electrolyte balance, acoustic impedance, and sonographic pattern can affect echogenicity. Therefore, random measurements performed for ASER analysis can decrease the reliability of the method; it should be performed by radiologists having experience in this procedure. The area to be measured should be chosen with extreme care, multiple measurements should be made from the areas free from ultrasonographic artifacts, and the average of these measurements should be calculated.

In conclusion, according to our findings, the determination of ASER and serum procalcitonin levels seems to provide satisfactory diagnostic accuracy in differentiating ascites infections in hospitalized patients with all-cause liver cirrhosis with a cut-off value of 0.5 for procalcitonin levels and 0.0019 for ASER in clinical use. Given that performing ascitic fluid culture examination is time consuming and not always available in an emergency setting, ASER and high procalcitonin levels should be considered in combination with a high PMNL count in the differential diagnosis of patients with ascites. ASER, in particular, can be used as an additional, easily applicable noninvasive ultrasonographic method with a higher sensitivity and specificity in the determination of ascites infection. Further, ASER was a better diagnostic marker than procalcitonin level for the detection of ascites infection. Further large-scale studies are needed to confirm the predictive role of ASER in infected and sterile ascites in cirrhotic patients.

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Original Article

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