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Original Research Article

Ascitic fluid analysis with special reference to serum ascites cholesterol gradient and serum ascites albumin gradient

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ABSTRACT

Background: Ascites being a common clinical problem with a vast spectrum of etiologies, less expensive and widely available biochemical parameters are required to differentiate ascites which can correlate with pathogenesis and pin point towards an etiology with high sensitivity and significant accuracy. Aims of the study were to determine the sensitivity, specificity and diagnostic efficacy of serum ascites albumin Gradient (SAAG) and that of ascitic fluid total protein (AFTP), evaluating their diagnostic role in identifying the etiology of ascites, to determine the diagnostic efficacy of Ascitic fluid cholesterol and serum ascites cholesterol gradient (SACG) in diagnosis of malignant ascites.
Methods: In this study, 100 patients of ascitis were evaluated for ascitic fluid total protein, albumin, cholesterol, SAAG and SACG along with ultrasound and other required investigations.
Results: Sensitivity, Specificity, and Diagnostic accuracy of SAAG for Portal hypertension were 97%, 85%, 96% respectively, whereas those of AFTP for exudative/transudative ascitis were 78.5%, 66%, 68% respectively. Ascitic fluid cholesterol and Mean SACG were significantly elevated in malignant ascites when compared with Non-Malignant Ascitis with p=0.0001. Similarly with a cut off level of 70mg% and 54 mg%, Ascitic fluid cholesterol and Mean SACG are having diagnostic accuracy of 90% and 93% respectively.
Conclusions: SAAG is much more superior to AFTP in differential diagnosis of Ascitis. Ascitic fluid cholesterol and Mean SACG are simple and cost effective methods to separate malignant ascitis from non-malignant causes even in small centres with limited diagnostic facilities.

Keywords: Malignant ascitis, Portal hypertension, Serum ascites cholesterol gradient, Serum ascites albumin gradient

INTRODUCTION

Ascitis defined as accumulation of free fluid in the peritoneal cavity is a commonly encounterd clinical condition having varied etiologies and pathogenesis. Analysis of Ascitic fluid is the easiest and most useful way to pin-point the cause. Etiologically, Cirrhosis is the most common (84%), others being Cardiac ascites, infection (tuberculosis), peritoneal carcinomatosis, pancreatitis, and renal disease (nephrotic syndrome). Many causes are mixed resulting from cirrhosis and a second disease.[1] Pathophsiologically, Ascitis may be due to Portal Hypertension (Ex-Cirrhosis) or causes due to pathology of peritoneum, which are not related to portal hypertension (Ex-Tubercular Peritonitis, peritoneal carcinomatosis). Previous classification of Exudative and Transudative Ascitis based on AFTP is unable to correctly identify the aetiological factors and offers little insight to the pathophysiology of ascitic fluid formation.[2,3] It has been challenged in clinical conditions especially in cirrhotic patients on prolonged diuretic theray, cardiac ascites, malignant ascites, and Mixed

ascitis like cirrhotic patients with spontaneous bacterial peritonitis.[4-7]

Hence – SAAG [Serum Ascites Albumin Gradient] has been developed as a new approach, to classify ascites into two categories – High SAAG ascites with SAAG ≥1.1 g/dl in cases with portal hypertension and Low SAAG ascites with SAAG <1.1 g/dl in cases with ascites, unrelated to portal hypertension. SAAG reflects the oncotic pressure exerted by Serum Albumin over Ascitic fluid Albumin which truly equals the high hydrostatic pressure gradient between the portal bed and the ascitic fluid.

Therefore the difference between the serum and the ascitic fluid albumin concentrations correlates directly with portal pressure. SAAG classification is much more physiologic and correlates well with the pathogenesis even in patients on diuretic, cardiac ascitis and mixed ascitis. Various studies have shown superiority of SAAG in classifying ascites compared to transudate-exudate concept.[8-10] The present study has been undertaken to compare sensitivity and diagnostic accuracy between SAAG and AFTP in the differential diagnosis of ascites.

Now Ascitis due to Malignancies are on rise and difficult to diagnose by routine Ascitic fluid analysis. Althouh SAAG accurately differentiate Ascitis due to Portal Hypertension from other causes, but SAAG is not able to differentiate between malignant ascites and tuberculous ascites as both are having low SAAG (<1.1 gm%).[11]

Fluid cytology has low sensitivity for malignancy as the differentiation between reactive atypical mesothelial cells and malignant cells is sometimes difficult.[12,13] Most of the time, diagnosis in not possible without invasive and expensive investigations like CT abdomen, Biopsy and FNAC of peritoneal nodes and diagnostic laparotomy/laparoscopy. So there is a need for more specific and a highly sensitive new marker in presumptive diagnosis of ascites.

There are few studies regarding ascitic fluid cholesterol level and SACG (serum ascites cholesterol gradient) as a sensitive, cheap and non-invasive parameter in diagnosing malignancy related ascites.[13-17] According to Rana et al, Total Ascitic protein (70%), Ascitic serum protein ratio (74%), ascitic leukocyte count (54%), and malignant cytology (82%) yielded much lower diagnostic efficiency than ascitic fluid cholesterol (94%) in the diagnosis of malignant ascites.[13]

Again a study by Sapna Vyakaranam et al shows cholesterol has been found to clearly differentiate between tuberculous and malignant ascites.[17] The elevated cholesterol levels in malignancy is due to the increased vascular permeability, increased cholesterol synthesis and release from malignant cells implanted on peritoneum.[13,18] As studies on this are very less, hence the present study has been undertaken to evaluate sensitivity and diagnostic accuracy of ascitic fluid cholesterol level and SACG in diagnosing malignant ascitis.

METHODS

This Prospective observational study on "ascitic fluid analysis with special reference to SAAG and SACG" has been carried out in in Department of Medicine, MIMS, Vizianagaram, a tertiary teaching hospital in North Andhra Pradesh during 2013 to 2016. The study was approved by Intuitional ethical committee and an informed written consent was obtained from patient.

Inclusion criteria

- Patients with ascites proved by ultra sound
- Patients aged more than 18 years.
- Patients with normal coagulation profile.

Exclusion criteria

- Patients with blunt injury abdomen,
- Patients with coagulopathy or disseminated intravascular coagulation (DIC).

All patients with ascites were subjected to detailed history and thorough clinical examination, a base line investigation - CBP, Urine Analysis, LFT, RFT, Serum Cholesterol, Serum Albumin, ECG, CXR and ultrasound scan of abdomen were performed.

Diagnostic paracentesis was done with prior written consent using 20-22 gauge 2.5 inch disposable needles under sterile precautions using Z tract Technique. Around 50 ml fluid was aspirated and fluid was immediately sent for Biochemical Analysis for Albumin, Total Protein, Cholestrerol, Glucose, Amylase, LDH, and ADA, Cytological Analysis for Cell counts and Differential count, and Microbiological Analysis for gram stain, ZN stain and bacterial culture.

Serum and Ascitic fluid Albumin were estimated in autoanalyser by Bromocresol green. Total Protein were estimated in autoanalyser by Biuret methods. The serum cholesterol and Ascitic fluid cholesterol were also estimated. Serum samples for Cholesterol and Albumin were also sent at same time as Ascitic fluid sample for accurate calculation of SAAG and SACG. SAAG and SACG were calculated simply subtracting the ascitic fluid value from the serum value.

Special investigations like CT scan abdomen and Pelvis. Echocardiogram, Thyroid Profile, Upper GI endoscopy, and FNAC of the peritoneal nodules and liver biopsy were done in selected cases.

- Diagnosis of liver cirrhosis conformed by clinical features of Portal HTN and Hepato-cellular failure, alcoholic history, and ultra sound (Coarse hepatic echotexture with nodularity, Dilated collaterals

around the gastroesophageal junction and splenic hilum, Splenomegaly and dilated portal vein >14 mm in diameter and splenic vein >12 mm).
- Heart diseases conformed by clinical history, ECG, 2D echo, X ray chest.
- HCC and malignant deposit in liver conformed by clinical history, liver biopsy. Alfa-fetoprotein, ultra sound abdomen, and CT abdomen.
- Peritoneal carcinometosis conformed by clinical history, ultra sound abdomen, CT abdomen, FNAC of peritoneal nodes and Ascitic fluid study for malignant cells.
- TB peritonitis conformed by clinical history, ultra sound abdomen, ascitic fluid ADA, ascitic fluid grams stain, ascitic fluid AFB.
- Nephrotic syndrome conformed by clinical history, ultra sound abdomen, Urine albumin, 24 hours urinary protein, lipid profile, blood urea, serum creatinine.
- Pancreatitis conformed by clinical history, ultra sound abdomen, CT abdomen, serum amylase, serum lipase, asctic fluid amylase.
- Esophageal varices conformed by upper GI Endoscopy.

Statistical analysis

The data was processed in MS Excel and analysis was carried out using SPSS (17th version). The results were statistically analyzed by unpaired Student't' test and by Pearson's correlation coefficient. A two tailed probability value of <0.05 was taken as indicating significance.

RESULTS

100 cases of Ascitis in the age range of 18 to 75 were included in the study irrespective of etiology. The distribution of ascites among the males and the females was more or less equal with 56 males (56%) and 44 (44%) females with a sex ratio of 1.27. Majority of the cases i.e. 90 (90%) are aged above 30 years, and the total number of cases 24 (24%) peaks around 51-60.

Table 1: Etiological distribution.

Aetiology	Total number (n=100)
Cirrhosis	54
Decompensated heart failure	12
Tuberculous ascites	10
Nephrotic syndrome	08
Hepatocellular Carcinoma	4
Peritoneal carcinomatosis	8
Pancreatitis	04

Table 1 shows cirrhosis of the liver (54%) ranked first followed by decompensated heart failure (12%), malignant ascites (12%) and tuberculous peritonitis (10%).

There were 12 cases of malignant ascites among which 4 were cases of HCC, and 8 were cases of peritoneal carcinomatosis with Primaries in Colon (5) and Stomach (3).

Table 2: Distribution of ascites on the basis of ascitic fluid total protein.

Etiology	AFTP≥2.5	AFTP<2.5
Cirrhosis	16	38
Decompensated heart failure	6	6
Nephrotic syndrome	4	4
Hepatocellular carcinoma	2	2
Tuberculous ascites	8	2
Peritoneal carcinomatosis	6	2
Pancreatitis	04	0

Table 3: Comparison of AFTP and exudative/ transudative.

Pathophysiology	Exudate (Expected AFTP>2.5) -26	Transudate (Expected AFTP <2.5-74
AFTP>/=2.5	20 (True positive)	26 (False positive)
AFTP<2.5	06 (False negative)	48 (True negative)
Sensitivity	76.92%	
Specificity	64.86%	
Positive predictive value	43.47%	
Negative predictive value	88.88%	
Diagnostic accuracy	68%	

Basing on Pathophysiology of Ascitis, 70 cases of ascites were expected to have portal hypertension related etiology (Cirrhosis 54+ Heart Failure+ Hepatocellular Carcinoma 4) and 30 remaining cases without portal hypertension (Tuberculous ascites 10+ Pancreatitis 04 +Peritoneal carcinomatosis 08) which was subsequently confirmed by Presence or Absence of Ultrasonographic findings suggestive of Portal Hypertension.

The five variables calculated for both SAAG and AFTP are noted in Table: 7, clearly indicates with no doubt that SAAG is a significantly better parameter than AFTP in determining the etiology of ascites and correlates well with the pathogenesis, i.e., Presence of portal Hypertension or not.

Table 4: Distribution of ascites on the basis of SAAG.

Etiology	SAAG≥1.1	SAAG<1.1
Cirrhosis	52	02
Decompensated heart failure	12	00
Nephrotic syndrome	00	08
Hepatocellular Carcinoma	04	00
Tuberculous ascites	02	08
Peritoneal carcinomatosis	00	08
Pancreatitis	00	04

Table 5: Comparison of SAAG and portal hypertension.

Pathophysiology	Portal HT (expected high SAAG) -70	Non Portal HT (expected low SAAG) -30
High SAAG (>1.1)	68 (True positive)	2 (False positive)
Low SAAG (<1.1)	2 (False negative)	28 (True negative)
Sensitivity	97.14%	
Specificity	93.33%	
Positive predictive value	97.14%	
Negative predictive value	93.33%	
Diagnostic accuracy	96%	

Table 6: Comparison of mean SAAG with mean AFTP in cases of Ascites having portal hypertension from others with normal portal pressure.

	Portal Hypertension (n=70)	Non Portal Hypertension(n=30)	P value
Mean AFTP (gm/dl)	1.79±0.71	3.1±0.34	<0.001
Mean SAAG (gm/dl)	2.15±0.30	0.71±0.17	<0.001

Table 7: Comparison of AFTP and SAAG in differential diagnosis of ascitis.

Parameters	AFTP	SAAG
Sensitivity	76.92%	97.14%
Specificity	64.86%	93.33%
Positive predictive value	43.47%	97.14%
Negative predictive value	88.88%	93.33%
Diagnostic accuracy	68%	96%

Table 8: Comparison of the diagnostic accuracies of SAAG and AFTP as per etiology in present study.

Etiology	SAAG	AFTP
Cirrhosis	96.29%	70.32%
Decompensated heart failure	100%	50%
Tuberculous ascites	80%	80%
Nephrotic syndrome	100%	50%
Hepatocellular Carcinoma	100%	50%
Peritoneal carcinomatosis	100%	75%
Pancreatitis	100%	100%

Table 8 shows that even for individual etiologies, diagnostic accuracies of SAAG are much better than AFTP especially in Cirrhosis, Decompensated heart failure, Nephrotic syndrome and Malignant Ascitis.

Table 9: Analysis of mean ascitic fluid cholesterol and mean SACG in distinguishing malignant from non-malignant ascitis.

	Malignant Ascitis (n=12)	Non-Malignant Ascitis (n=88)	P value
Ascitic fluid Cholesterol (gm/dl)	128.6±8.10	51.40±8.3	<0.001
Mean SACG (gm/dl)	36.4±6.80	72.4±6.8	<0.001

The p<0.0001 for both parameters which is statistically highly significant

As shown in Table 10, at a cut off level of 70mg%, Ascitic fluid cholesterol has sensitivity 88%, specificity 96%, positive predictive values 94%, negative predictive value 95% and diagnostic accuracy 90%. Similarly At a cut off level of 54mg%, SACG has sensitivity 90%, specificity 95%, positive predictive values 84%, negative predictive value 96% and diagnostic accuracy 93%.

Table 10: Diagnostic values SACG and ascitic fluid cholesterol in separating malignant from non-malignant ascites.

Parameter	Cut off value	Sensitivity	Specificity	Positive predictive valu	Negative predictive value	Diagnostic accuracy
Ascitic fluid cholesterol (mg/dl)	>70	88%	96%	94%	95%	90%
SACG (mg/dl)	< 54	90%	95%	84%	96%	93%

DISCUSSION

For many years, the ascitic total protein concentration has been used to determine whether ascitic fluid was a transudate (AFTP<2.5 gm%) or exudate (AFTP ≥2.5 gm%). These exudates – transudate concept was based on the fact that exudates fluid is from the inflamed and tumor laden peritoneal surface hence it is high in protein suggestive of Peritonitis or Malignant ascitis. The transudate fluid is from normal peritoneal surface and is low in protein and is formed commonly due to increase in portal pressure in accordance with Starling hypothesis. Various studies have challenged accuracy of traditional exudates-transudate concept which does not truely reflect the pathophysiology.

Again the relationship between ascitic protein concentration and character as transudate or exudates does not hold true in many conditions as it does not take the value of serum albumin into account. According to Akriviadis et al, it has certain limitations: i) The ascitic fluid total protein of most cardiac ascites samples (traditionally expected to be transudate) was high.[19] ii) Ascitic fluid total proteins of most spontaneously infected samples (traditionally expected to be exudate) was low iii) The efficacy has also been challenged in of relatively high serum protein concentration especially in Compensated Cirrhosis and Pt. on Diuretic therapy where AFTP is high although a transudate. Also in almost one third of patients with malignant ascites, the ascites is caused by massive liver metastasis or hepatocellular carcinoma and the ascitic fluid in these patients has a low protein concentration supposed to be exudate .Gupta et al. reported that 24% of patients with uncomplicated cirrhosis had an ascitic total protein concentration greater than 2.5 gm% suggestive of Exudate and Alexandrakis et al. reported that 20% of malignant ascites cases had protein concentration <2.5 gm% suggestive of Transudate.[20,21] Present study also supports the above fact as it shows diagnostic accuracies of AFTP in Cirrhosis, Heart Failure and Malignancy is 70.37%, 50% and 66% respectively which is much less than that of SAAG which is 96.29%,100% and 100% respectively.

Hence superseding AFTP, SAAG defined as the serum albumin concentration minus the ascitic fluid albumin concentration, had been proposed as a physiologically based alternative in the classification of ascites first by Hoefs more than 20 years ago.[22] Thereafter, several investigators have also demonstrated superiority of SAAG in distinguishing portal hypertensive ascites (SAAG >11 g/L) and non-portal hypertensive ascites (SAAG <11 g/L).[3,8,9] Portal hypertension results in an abnormally high hydrostatic pressure gradient between the portal bed and the ascitic fluid. A similarly large difference must exist between the ascitic fluid and the intravascular oncotic forces. As albumin is major determinant of oncotic pressure in the serum, SAAG is

directly related to oncotic pressure gradient and thus proportional to portal pressure gradient and does not vary even in patients treated with diuretics, heart failure, albumin infusion and in presence of SBP.[5,7] A serum ascites albumin gradient >1.1 gm/dl is suggestive of portal hypertension not only in patients with transudative type of ascites but also in cases with high protein concentration. Presently SAAG is included in the guidelines of investigations recommended on the management of ascites in cirrhosis by American Association of the Study of Liver Disease (AASLD) and British Society of Gastroenterology.[23,24]

Above views are supported in present study which shows Diagnostic accuracy, Sensitivity, Specificity, Positive predictive value (PPV) , Negative predictive value (NPV) and Diagnostic accuracy of SAAG and Portal hypertension were 97%, 85%, 94%, 92%, 96% respectively, whereas those of AFTP and exudative/ transudative ascitis were 78.5%, 66%,48%, 89%,68% respectively. All data's tabulated and analysed above validated high statistical significance.

Other studies having similar results are

In a study by Sapna Vyakaranam et al, diagnostic accuracy, Sensitivity, Specificity, Positive predictive value (PPV) and Negative predictive value (NPV) of SAAG were 94%, 96%, 92%, 92.3%, and 95.8% respectively, whereas those of AFTP were 86%, 80%, 92%, 90%, and 82% respectively.[17]

Another study by Muhammad Younas et al found Diagnostic accuracy, Sensitivity, Specificity, Positive predictive value (PPV) and Negative predictive value (NPV) of SAAG were 96%, 97%, 95%, 98.6%, and 90% respectively, whereas those of AFTP were 56%, 53%,70%, 86%, and 29% respectively.[25]

Another prospective study done by M Beg, S Husain et al and they were observed that the serum albumin ascitic gradient had a diagnostic sensitivity of 94.73% and 94% accuracy compared to AFTP, which is 65.62% and 68% respectively.[26]

A large study of 901 patients conducted by Bruce A. Runyon et al, Montano AA et al, Akriviadis EA et al, Antillon MR et al, Irving MA et al. and McHutchison JG et al. in the University of Iowa, Iowa city in 1992 also reveals diagnostic accuracy of SAAG and ascitic fluid total protein to be 96.7% and 55.6% respectively.[27]

In present study, the ascitic fluid cholesterol and Mean SACG were significantly elevated in malignant ascites (128.6±8.10mg % and 36.4±6.80 respectively) when compared with Non-Malignant Ascitis (51.4±8.3mg % and 72.4±6.8 respectively).The p=0.0001 for both parameters which is statistically highly significant. Prieto etal28 showed that ascitic fluid cholesterol concentrations were significantly higher in patients with peritoneal metastases and was superior to ascitic fluid total protein, lactate dehydrogenase and SAAG for discriminating ascites from that due to liver disease Similar results were found by Sharatchandra LK et al in which the SACG values in cirrhosis, tuberculosis and malignancy were 99.2±27.8, 54.16±36.26 and 50±23 respectively with a sensitivity of 80%. Similarly another study30 done by Goran BJELAKOVI and his colleagues also showed cholesterol were significantly higher in malignant than in cirrhotic ascites.[29]

In addition, present study shows that at a cut off level of 70mg%, Ascitic fluid cholesterol has sensitivity 88%, specificity 96%, positive predictive values 94%, negative predictive value 95% and diagnostic accuracy 90%. In separating malignant from Non-malignant ascites. Similarly At a cut off level of 54mg%, SACG has sensitivity 90%, specificity 95%, positive predictive values 84%, negative predictive value 96% and diagnostic accuracy 93% in separating malignant from Non-malignant ascites

This is supported by study by Vyakaranam S, et al which reveals that with a critical value of >62mg%, the diagnostic accuracy of Ascitic fluid cholesterol was 96% and with a critical value of 53mg% SACG differentiated malignant ascites from cirrhotic and tuberculous ascites by a diagnostic accuracy of 94%.[17] Similarly as pre Rana et al using a cut-off value of 70 mg/dl, the specificity of Ascitic fluid cholesterol is 100% and sensitivity is 96% in diagnosis of malignancy.[13] Other studies like Sharatchandra et al and Ranjith et al also supports it.[15,16]

Mechanism of raised Ascitic fluid cholesterol in Malignant Ascitis

An enhanced movement of plasma lipoproteins like LDL and HDL into peritoneal cavity due to increased permeability of malignant serosal epithelia is likely explanation of the raised cholesterol levels especially in Peritoneal Carcinomatosis as described by Jungst et al.[31]

It has also been suggested that a minor fraction of cholesterol in malignant ascites might be derived from fragile cell membranes of malignant cells as cholesterol is a constituent of cell membrane (Gerbes et al).[32]

Third mechanism may be due to obstruction in lymph flow causing a rupture of lymphatic channel, which leads to secretion of chyle into the peritoneal cavity.

The present study observed that 70 of 100 (70%) patients had High SAAG and 30 of 100 (30%) had Low SAAG. Esophageal varices were present in 67 of 70 (95.71%) patients with High SAAG and 2 of 30 (6.66%) patients with Low SAAG which shows positive correlation between high SAAG value and association of varices.

A similar one studied by Gurubacharya DL and his colleagues and the study revealed that 25 of 32 (78.13%)

patients had High SAAG and 7 of 32 (21.87%) had Low SAAG.[33] Oesophageal varices were present in 18 of 25 (72%) patients with High SAAG and in none of 7 (0%) patients with Low SAAG.

CONCLUSION

- The present study concluded the following important observations.
- The presence of high SAAG indicates portal hypertension even in presence of high ascetic fluid protein. It is superior to previously proposed transudate-exudate classification, because of its higher diagnostic accuracy and it provides a better approach to pathogenesis of ascitic fluid collection
- Diagnostic accuracy, Sensitivity, Specificity, Positive predictive value (PPV), Negative predictive value (NPV) and Diagnostic accuracy of SAAG is very much superior to AFTP in differential diagnosis of ascitis.
- SAAG does not provide exact aetiology of ascites especially in low SAAG conditions like Tubercular and Malignant Ascitis.
- Ascitic fluid cholesterol and Mean SACG are highly sensitive, specific and are having high Diagnostic accuracy of 90% and 93% with a a cut off level of 70mg% and 54 mg% respectively. Hence being simple and cost effective, these can be widely utilized to separate malignant ascitis from non-malignant causes even in small centres with limited diagnostic facilities.
- Having positive correlation between high SAAG value and association of varices, SAAG can be a cheap, simple and easy alternative to Upper GI Endoscopy to predict variceal bleeding and patient of Portal Hypertension can be put on prophylactic therapy considering the significant SAAG value.

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REFERENCES

1. Fauci, Braunwald, Kasper, Hauser, Longo, Jameson, et al. Cirrhosis and its complications, Harrison's principles of internal medicine, 19th edition. Nework, McGraw Hill publications, 2015:2058-67.
2. Sampliner RE, Iber FL. High protein ascites in patients with uncomplicaed hepatic cirrhosis. Am J Med Sci. 1974;267:275-9.
3. Rector WG, Reynolds TB. Superiority of the serum-ascites alubumin difference over the ascites total protein concentration in separation of 'transudative' and'exudative' ascites. Am J Med. 1984;77:83-5.
4. Hoef JC. Increase in ascitic WBC and protein concentration during diuresis in patients with chronic liver disease. Hepatology. 1981;1:249-54.
5. Runyon BA. Cardiac ascites: A characterization. J ClinGastroenterol. 1988;10:410-2.
6. Runyon BA, Hoefs JC, Morgan TR. Ascitic fluid analysis in malignancy-related ascites. Hepatology. 1988;8:1104-09.
7. Runyon BA. Low protein concentration ascitic fluid is predisposed to spontaneous bacterial peritonitis. Gastroenterology. 1986;91:1343-6.
8. Runyon BA, Montano AA, Akriviadis EA, Antillon MR, Irving MA, McHutchison JG. The serum – ascites albumin gradient is superior to the exudate-transudate concept in the differential diagnosis of ascites. Ann Intern Med. 1992;117:215-20.
9. Goyal AK, Goyal SK, Pokharna DS, Sharma SK. Differential diagnosis of ascitic fluid: Evaluation and comparison of various biochemical criteria with a special reference to serum ascites albumin concentration gradient and its relation to portal pressure. Trop Gastroenterol. 1989;10(1):51-5.
10. Gupta R, Misra SP, Dwivedi M, Misra V, Kumar S, Gupta SC. Diagnostic ascites: Value of total protien albumin, cholesterol their ratios serum ascites albumin and cholesterol gradient. J Gastroenterol Hepatol. 1995;10(3):295-9.
11. Alba D, Torres E, Vazquez JJ. Sero–ascitic gradient of albumin: usefulness and diagnostic limitations 1995;12(8):404-7.
12. Jain SC, Misra SM, Misra NP and Tandon PL. Diagnostic value of ascitic fluid xamination. J Asso Physic India. 1996;14:59-69.
13. Rana SV, Babu SG, Kocchar R. Usefulness of ascetic fluid cholesterol as a marker for malignant ascites. Med SciMon. 2005;11:136-42.
14. Prieto M, Gomez-Lechon MJ, Hoyos M. Diagnosis of Malignant ascites. Comparison of ascitic fibrinonectin, cholesterol, and serum-ascites albumin difference. Dig Dis Sci. 1988;33:833-38.
15. Sharath Chandra LK, Mingsen T, Singh YI. Serum ascites lipid gradients in alcoholic liver cirrhosis, tuberculosis and malignancy. JIACM. 2005;6:106-9.
16. Ranjith D, Ranjith MP, Dutta D, Krishnan MG, KamalRaj R, Vinu K. Ascitic fluid lipid profile and albumin level. Bangladesh Medi Rese Coun Bulletin. 2010;1(36):34-6.
17. Vyakaranam S, Nori S, Sastry GM, Vyakaranam SB, Bhongir AV. Serum - Ascites Albumin and Cholesterol Gradients in Differential Diagnosis of Ascites. NJIRM. 2011;2(3):22-8.
18. Sood A, Garg R, Kumar R. Ascitic fluid cholesterol in malignant and tubercular ascites. J Asso Physicians India. 1995;43(ii):745-7.
19. Akriviadis EA, Kapnias D, Hadjigavriel M, Mitsiou A and Goulis J. Serum/Ascites Albumin Gradient: Its Value as a Rational Approach to the Differential Diagnosis of Ascites. J Gastro. 1996;31(8) 814-7.
20. Gupta R, Misra SP, Dwivedi M, Misra V, Kumar S, Gupta SC. Diagnosing ascites: value of ascitic fluid total protein, albumin, cholesterol, their ratios, serum-ascites albumin and cholesterol gradient. J Gastroenterol Hepatol. 1995;10:295-9.

21. Alexandrakis MG, Moschandrea JA, Koulocheri SA, Kouroumalis E, Eliopoulos GD. Discrimination between malignant and nonmalignant ascites using serum and ascitic fluid proteins in a multivariate analysis model. Dig Dis Sci. 2000;45:500-8.
22. Hoefs J. Serum protein concentration and portal pressure determine the ascitic fluid protein concentration in patients with chronic liver disease. J Lab Clin Med. 1983:102:260.
23. Runyon BA. Management of adult patients with ascites due to cirrhosis. Hepatology. 2004;39:841-56.
24. Moore KP, Aithal GP. Guidelines on the management of ascites in cirrhosis. Gut. 2006(Suppl 6):vi1–vi12.
25. Younas M, Sattar A, Hashim R, Ijaz A, Dilawar M, Manzoor SM, et al. Role of serum-ascites albumin gradient in differential diagnosis of ascites. J Ayub Med Coll Abbottabad. 2012;24(3-4):97-9.
26. Beg M, Husain S, Ahmad N, Akhtar N. Serum/Ascites Albumin Gradient in Differential Diagnosis of Ascites. J Indian Acad Clin Med. 2001;2(1):51-4.
27. Runyon BA, Montano AA, Arkiviadis EA. The serum ascites albumin gradient in the differential diagnosis of ascites is superior to exudates/transudate concept. Ann. Intern Med. 1992;117;215-20.
28. Morsy KH, Ghaliony MAA, Mohamed HS, ElMelegy TTH. Diagnostic Value of Serum Ascites Lipid Gradients in Patients with Ascites. J Liver. 2014;3:165.
29. Porwal V, Porwal A, Ajnar Y, Verma A, Pandey P. Estimation of serum ascitic albumin gradient (saag) and serum ascitic cholesterol gradient (sacg) in different causes of ascites. Çağdaş Tıp Dergisi, 2016;6(3):150-6.
30. Bjelakovi G, Tasi T, Nkovi IS, Stojkovi M, Kati V, Marica et al. Biochemical, cytological and microbiological characteristics of the cirrhotic, malignant and mixed ascites Archive of Oncology. 2001;9(2):95-101.
31. Gurubacharya DL, Mathura KC, Karki DB. Correlation between serum-ascites albumin concentration gradient and endoscopic parameters of portal hypertension, Kathmandu University Medical Journal. 2005;3(4):327-33.
32. Jungst D, Xie Y, Gerbes AL. Pathophysiology of elevated ascites fluid cholesterol in malignant ascites. Increased ascites to serum relation of proteins & lipoproteins in patients with peritoneal carcinomatosis as compared to patients with cirrhosis of the liver. J Hepatology. 1992;14(2-3):244-8.
33. Gerbes AL, Xie Y, Meeger J, Jungst D. Ascitic fluid concentration of fibronectin and cholesterol: comparison of differential diagnosis value with the conventional protein determination. Liver. 1990;10:152-7.

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