CASE REPORTS

A formula to estimate water loss in a malnourished patient with ascites: One inch equals one kilogram

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ABSTRACT

Severe ascites accounts for a large percentage of body water, making measurements of lean body mass (LBM) inaccurate. There are no bed-side methods to determine the contribution of ascites to LBM. Using the formula for a sphear, a patients volume of ascites was obtained by the standard equation (Volume = 4/3 × Pi × [radius]^3). A 54-year-old malnourished Hispanic female with Child's Class C liver cirrhosis presented to the ER with 2-weeks of increasing abdominal pain, girth, fever, chills and decreased nutritional intake. The admission abdominal girth measured 106 cm at the umbilicus. The radius of the sphere was obtained measuring the abdominal girth divided by two times Pia times radius (radius = 106 cm/[2 × 3.14] = 16.9 cm). Using the above calculated radius of 16.9 cm, Volume = 4/3×3.14 × 16.9 cm^3 = 20,208 cc = approximate volume of the abdomen at presentation. Using the same formulas, abdominal volume was 8,275 cm cubed seven days after discharge from hospital. The difference in abdominal volume from admission to follow up is 20,208 cc-8,375 cc = 11,833 cc, assuming a specific gravity of 1.0, 11.8-liters of volume or kg of weight. The amount of ascitic abdominal fluid lost was confirmed by comparing change in volume to change in body weights (66.0 kg-55.0 kg, admission and follow-up weights, respectively). The 11.0 kg weight loss was similar to the estimated change in abdominal body water change of 11.8 kg. Conclusion: The simple measurement of waist circumference may provide an estimate of ascites volume and changes in volume should be similar to changes in weight. For every 2.4 cm (1 inch) that the waist circumference is reduced, body weight (and ascites) should be reduced by 1-kilogram.

Key Words: Cirrhosis, Branched-chain amino acids, Anthropodometry, Anthropometrics, Third spacing, Tissue edema, Ascites, Spontaneous bacterial pertionitis

1. INTRODUCTION

Earlier work with 23 cirrhotic patients with cirrhosis demonstrated that 46% of measured weight loss was due to a reduction in measured ascites volume using methylene blue dilution to measure the volume.[1] This is the first report using the formula of a sphere to estimate ascites volume and relate this to change in weight loss after resolution of the ascites volume.

2. CASE REPORT

A 54-year-old malnourished Hispanic female with Child's Class C liver cirrhosis presented to the emergency department with 2-weeks of worsening abdominal pain, increasing abdominal girth, fever, chills and decreased oral intake. Admission weight was 66.0 kg. The physical exam revealed scleral icterus, a soft but distended abdomen measuring 106 cm in circumference, tender to palpation in all four quadrants,

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and extremity examination revealed 2+ edema. Admission laboratory values revealed an albumin of 1.5 mg/dl, INR of 1.6, BUN 50. Paracentesis on admission revealed ascitic fluid containing 2,100 white blood cells. She was subsequently treated for spontaneous bacterial peritonitis (SBP) with 1g IV Ceftazidime. The patient continued to have fevers despite ceftazidime treatment and a second paracentesis evidenced continuous infection with neutrophils (74%) so Ceftazidime was replaced with Piperacillin-tazobactam (Zosyn). Throughout the course of her stay the patient was placed on a high branched chain amino acids (BCAA) supplement called NutraHep (1 can twice a day) and partial parenteral nutrition consisting of 50% BCAA. The patient's symptoms improved with continued antibiotic and nutritional therapy and she was subsequently discharged home with medications for SBP prophylaxis and portal hypertension as well as nutritional therapy NutraHep. The patient's albumin level at discharge was 2.2 mg/dl and her abdominal circumference measured one week after her discharge date was noted to be 79 cm and her weight was 55 kg.

The above case provides an opportunity to derive a simple formula to estimate ascitic fluid volume semicolon, which may be used as a potential objective marker to monitor response to therapy. Using the formula to determine the volume of a sphere, we can estimate the volume of the abdominal contents given the patient's abdominal circumference. In the above case admission abdominal girth measured at 106 cm. The radius of the sphere can be obtained by dividing the circumference by $2 \times$ Pi. (radius = 106 cm/[2×3.14] = 16.9 cm). The approximate volume of the abdomen can be estimated from the formula to determine the volume of a sphere, $4/3 \times \text{Pi} \times (\text{radius})^3$. Using the above calculated radius of 16.9 cm, Volume = $4/3 \times 3.14 \times 16.9\ \text{cm}^3$ = 20,208 cc = approximate volume of the abdomen at presentation.

Using the same formulas, we can estimate the patient's abdominal volume at her 1-week outpatient clinic visit using her abdominal circumference, which was measured at 79 cm. radius = 79 cm/(2×3.14) = 12.6 cm; and Volume = $4/3 \times 3.14 \times 12.63$ = 8,375 cc approximate volume of the abdomen at follow up. The difference in abdominal volume from admission to follow up is 20,208 cc–8,375 cc = 11,833 cc or, assuming a specific gravity of 1.0, 11.8 liters of volume and 11.8 kg of weight.

This approximation of the amount of ascitic fluid lost can be confirmed by comparing it to the difference of the admission and follow up visit weights. This difference in weight from the two visits is 11.0 kg (66.0 kg-55.0 kg) which is very similar to the amount of weight loss estimated by using the difference in ascitic fluid volume from admission to the follow up visit (11.8 kg as calculated above).

The extent of exactly what percentage of the additional 11,833 cc of abdominal volume was due to ascitic fluid was estimated by applying the Vitrea Imaging Software to an abdominal CT scan obtained at admission. Using this software semicolon allowed us to reconstruct a three-dimensional representation of the ascitic fluid in the abdomen and then calculate the volume within it. We calculated the ascitic fluid volume to be 2,941 cc, which is 25% of the additional volume of the abdomen (11,833 cc). The remaining 75% of the volume may be attributed to edema semicolon of various tissues within the abdomen including the bowel and liver. A likely smaller amount of weight loss would be due to the loss of weight from the lower extremities. Earlier work with 23 patients with cirrhosis demonstrated that 46% of measured weight loss was due to a reduction in measured ascites volume using methylene blue dilution to measure the volume.[1] Using CT with volume ascites measurements documented that the water volume loss represented 25% of the total weight loss. Most of the loss was due to reduction in abdominal tissue, liver and other organ edema that resolved with resolution of the ascites and abdominal tissue edema.

The differences in volume and weight in this patient, pre and post treatment, compared to pre and post treatment abdominal circumference allows us to derive a simple formula to estimate excess abdominal fluid volume in patients with ascites. The 27 cm, or 10.6 inch, reduction of abdominal circumference measured in our patient correlates with 11.0 kg of weight reduction. By reducing the above terms we can then show that one-inch of abdominal girth loosely correlates with 1 kg of weight loss or 1 L of abdominal volume.

Patients with ascites have an increased energy expenditure, which falls after removal of the ascites.[2] Furthermore, increased calorie intakes have been associated with a prolonged 6-month survival in patients with severe ascites.[3] The decision to initiate a high calorie diet alone with BCAA supplemented nutritional therapy was made with consideration of the results from a year long, large multicenter, randomized controlled trial in 2003 semicolon comparing BCAA enriched nutritional therapy to lactoalbumin or maltodextrin in patient with liver cirrhosis. Patients who received BCAA therapy showed significant reduction in disease progression.[4]

Recent study using ultrasound demonstrated that 1 cm of ultrasound measurement in a pocket of ascites fluid relates to a 1 liter amount of fluid.[5] Using 1 cm as the measurement of diameter for volume measurement would extrapolate in the change in abdominal volume of 1.8 liters in your patient. Both the pocket measurement and the abdominal waist mea-

surement may be helpful tools to estimate ascites volume for the clinician.

3. CONCLUSION

The antibiotic treatment and the aggressive nutritional support resulted in complete resolution of this patient's ascites within a 16-day period. The simple measurement of waist circumference may provide an estimate of ascites volume and changes in volume should be similar to changes in weight. For every 2.4 cm (1 inch) that the waist circumference is reduced, body weight should be reduced by 1-kilogram. Ascites fluid accounts for only 25% of the observed weight loss after resolution of severe ascites and SPB. The majority of the weight and fluid loss is due to loss of fluid in edematous organs and subcutaneous tissue. Further work is needed to validate the easy use of abdominal waist circumference in estimating ascites volume and the response with therapy.

Consent

Written informed consent was obtained from the patient for publication of this case report.

Authors contributions

JT obtained data and finalized the draft report and validated all details of the case report.

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CONFLICTS OF INTEREST DISCLOSURE

The authors have declared no conflicts of interest.

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