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Measurement of Peritoneal Fluid pH in Patients with Non-Serosal Invasive Gastric Cancer

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The accurate pH range of peritoneal fluid is clinically valuable for the evaluation of some pathological conditions of the body, however, it is not easy to measure in healthy individuals. The aim of this study was to measure; pH, pCO_2, pO_2, Na^+, K^{++}, Ca^{++}, HCO_3^-, and O_2 saturation of the peritoneal fluid in patients with non-serosal invasive gastric cancer. One hundred and thirty four patients (86 men and 48 women), ranging in age from 24 to 91 years were enrolled in this study. After opening the abdominal wall, the probe of a portable pH meter was placed in the peritoneal fluid in the subhepatic space. In addition, I collected the peritoneal fluid from the subhepatic space to measure, pH, pCO_2, pO_2, Na^+, K^{++}, Ca^{++}, HCO_3^-, and O_2 saturation using an autoanalyzer. The pHs of the peritoneal fluids tested has a mean of 7.73 (range 7.46 - 8.10), and the other parameters were pCO_2, 22.81 mmHg; pO_2, 136.49 mmHg; Na^+, 146.57 mmol/L; K^{++}, 4.80 mmol/L; Ca^{++}, 0.89 mmol/L; HCO_3^-, 30.54 mmol/L, and O_2 saturation, 99.74%. This study describes a practical method of measuring the pH of peritoneal fluid. The result obtained reflects the normal adult peritoneal pH value, which I propose as a reference value.

Key Words: pH, peritoneal fluid, gastric adenocarcinoma

INTRODUCTION

Normally, there is about 100 mL of a clear, straw-colored fluid in the adult peritoneal cavity. The quality and quantity of the peritoneal fluid may change during pathological conditions of the body and of the peritoneum itself.[1,2] The Measurement of the peritoneal fluid pH is helpful for the diagnoses of several diseases. An acidic pH has been recorded in infected peritoneal fluid, intra-abdominal abscess, and tuberculous peritonitis.[3-5] Although the relationship between the pH of the peritoneal fluid and the presence of some diseases is important, and may be proven by statistical analysis, the diagnostic value of this parameter remains controversial.[1,6]

From the view points of methodology and medical ethics, the measurement of normal adult peritoneal fluid pH is not easy, and therefore, few reports on the pH of normal peritoneal fluid have appeared in the literature.

The objective of this study was to determine the normal pH range of peritoneal fluid in clinically stable patients with non-serosal invasive gastric adenocarcinoma.

The protocol used was approved by the Board of the Clinical Research Center at Chungnam National University Hospital and informed written consent was obtained from each patient.

MATERIALS AND METHODS

After receiving a final pathological report, patients with serosal invasion, or patients with lymph node invasion were excluded from this study.

Between August 1997 and June 2000, 134 patients with non-serosal invasive gastric adeno-

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carcinoma (86 men and 48 women) were enrolled for peritoneal fluid pHs measurement at the Chungnam National University Hospital, Daejeon, Korea. Median subject age was 60 years (range, 24 to 91 years). All patients had normal hepatic, cardio-pulmonary, and renal functions, according to the UICC classification of depth of invasion, there were 93 T1 cases, and 41 T2 cases.

A portable pH meter (IQ240 pH Meter, IQ Scientific Instruments, Inc. San Diego, CA, USA) was used to measure the pH of peritoneal fluid. This unit uses an ion-sensitive field effect transistor pH sensor. The probe contains a pH sensor, a reference electrode, and a temperature sensor. Temperature is compensated for automatically from -5℃ to +80℃, and the unit has a pH resolution of 0.001, for maximum accuracy. Before measuring the peritoneal fluid pH, the sensor was calibrated in buffer solutions of pH 7 and pH 9. The probe was cleaned throughout this work with de-ionized water.

After an overnight fast, about 1000 mL of 5% dextrose-normal saline solution was infused via the peripheral vein to the patient before and during anesthesia. An upper midline incision was carefully made on the abdominal wall, and the probe of the pH meter was placed in the peritoneal fluid in the subhepatic space.

In order to observe possible fluctuations of measured pH versus sample age, the peritoneal fluid specimens (in 1 mL Eppendorf® tubes) of 32 patients were exposed to room air and re-analyzed with the portable pH meter at 10 and at 20 minutes after the sampling.

For 68 of the 134 patients, peritoneal fluid pH and electrolyte were analyzed (i.e., pCO_2, pO_2, Na^+, K^{++}, Ca^{++}, HCO_3^-, and O_2 saturation) by using an autoanalyzer (Gem Premier Plus, Instrumentation Laboratory, Lexington, MA, USA), within 5 minutes of fluid collection. About 0.5 mL of the peritoneal fluid was drawn with a syringe, under sterile conditions, from blood or other tissue fluid at laparotomy. Simultaneously, a peripheral arterial blood sample was drawn from the radial artery and analyzed for the same parameters.

All statistical analyses were performed using SPSS version 10.0. Data are presented as means ± SEM. In addition, the independent-sample t-test, the paired-sample t-test and one-way ANOVA were used to compare the different groups. Statistically, $p < 0.05$ was considered significant.

RESULTS

Among the 134 patients, the mean (± SEM) pH of the peritoneal fluid was 7.73 (± 0.01) with a range of 7.46 to 8.10. Statistically, no significant differences in the pH were observed according to gender (p=0.092), age (p=0.844), or depth of tumor invasion (p=0.557) (Table 1).

The peritoneal fluid specimens of 32 patients were exposed to room air for 10 and 20 minutes after sampling to check for any fluctuations in the measured pH over time. The mean (± SEM) pH of the peritoneal fluid was 7.72 (± 0.01) when measured in the peritoneal cavity, and 7.73 (± 0.01) after 10 minutes, and 7.72 (± 0.01) after 20

Table 1. pH of Peritoneal Fluid in Sex, Age, and Depth of Tumor

	pH (M ± SEM)*	p value
Sex		0.092
Male	7.73 ± 0.01	
Female	7.72 ± 0.03	
Age (years)		0.844
~ 39	7.72 ± 0.02	
40 ~ 59	7.73 ± 0.01	
60 ~	7.73 ± 0.02	
Depth of tumor		0.557
T1	7.73 ± 0.02	
T2	7.73 ± 0.01	

*M ± SEM means mean plus-minus standard error of the mean.

minutes, and these differences were not significant (p=0.742) (Table 2).

For quality control purposes, the pHs of 68 of 134 samples were measured using a different analyzer. The mean (± SEM) peritoneal pH was 7.73 (± 0.01) with the portable pH meter and 7.72 (± 0.01) with the autoanalyzer, which was not significant (p=0.535).

The pH, pCO_2, pO_2, Na^+, K^{++}, Ca^{++}, HCO_3^-, and O_2 saturation results for peritoneal fluid and peripheral arterial blood samples are shown in Table 3.

DISCUSSION

The total area of the peritoneal surface is approximately 1.8 m^2 in adults. The peritoneum is formed from a single layer of mesothelial cells with an underlying supporting layer of highly vascularized loose connective tissue. The mesothelial lining cells secrete serous fluid and diaphragmatic lymphatic channels allow the peritoneal fluid to enter the venous circulation via the thoracic duct.

The pH of the peritoneal fluid was found to be higher than the pH of the blood in this study. The cause and clinical significance of the more alkaline pH of the peritoneal fluid remain an issue for study. The composition and nature of the peritoneal fluid are known to be altered by, pathological conditions affecting the mesothelial lining cells or the underlying connective tissue, and by systemic diseases. In the case of the later, the diagnostic value of peritoneal pH has been mentioned repeatedly in the literature.[1,6-8] In particular, the diagnostic value of the peritoneal fluid pH has been reported in cases of bacterial peritonitis and tuberculous peritonitis.[5,7,9] However the diagnostic specificity of this parameter has not been established.[3,4,7,9] The peritoneal membrane is a highly vascular structure, and its blood flow is further augmented as a normal response to acute inflammation in peritonitis. This accounts for the increased membrane permeability and poor ultrafiltration that typically occur during acute peritonitis. In addition, the peritoneal transport of fluid and small solutes might be influenced by the

Table 2. pH of Peritoneal Fluid Over Time

At laparotomy	10 minutes AS	20 minutes AS	p value
7.72 ± 0.01	7.73 ± 0.01	7.72 ± 0.01	0.742

The values are expressed as Mean ± SEM (Standard Error of the Mean).
AS is initial letters of after sampling.

Table 3. Mean ± SEM Ranges of pH, pCO_2, pO_2, Na^+, K^{++}, Ca^{++}, HCO_3^-, and O_2 Saturation in the Peritoneal Fluid and Peripheral Arterial Blood of 68 Patients

	Peritoneal fluid (M ± SEM)*	Blood (M ± SEM)	p value
pH†	7.73 ± 0.01†		
pH	7.72 ± 0.01	7.44 ± 0.01	0.000
pCO_2 (mmHg)	22.81 ± 1.18	35.87 ± 1.08	0.000
pO_2 (mmHg)	136.49 ± 0.66	223.56 ± 14.57	0.000
Na^+ (mmol/L)	146.57 ± 2.83	139.84 ± 0.54	0.001
K^{++} (mmol/L)	4.80 ± 0.17	3.68 ± 0.07	0.000
Ca^{++} (mmol/L)	0.89 ± 0.03	0.86 ± 0.03	0.964
HCO_3^- (mmol/L)	30.54 ± 0.79	24.33 ± 0.42	0.000
O_2 saturation (%)	99.74 ± 0.10	99.04 ± 0.70	0.289

*M ± SEM means mean plus-minus standard error of the mean.
†The value was determined using the portable pH meter, and the other values were obtained using the blood gas/electrolyte autoanalyzer.

acidity of the peritoneal fluid. The vasodilatory effect of an acidic solution provides a possible mechanism for these differences.[10]

A knowledge of the accurate pH range of normal peritoneal fluid is clinically valuable, but few reports exist in the literature or textbooks. The measurement of peritoneal fluid pH is easy and safe in a patient with a large amount of ascites. However, it is very hard to measure the pH of the peritoneal fluid in healthy adults due to ethical and technical concerns.

Alexandrakis et al.[11] reported that the pH of the peritoneal fluid cannot differentiate patients with serosal invasion from patients without serosal invasion in gastric adenocarcinomas. However, in the present study, patients with serosal invasion were excluded to ensure consistent results.

No significant fluctuation in the measured pHs was observed over time, by comparing the initial measurements taken in the peritoneal cavity, with those on 10 min and 20 min air exposed samples. Practically, this means that if the pH of the peritoneal fluid was measured post-laparotomy, that the pH's measured with an open or closed peritoneal cavity would be identical.

For the quality purposes, 68 samples were analyzed using a different analyzer, and no significant differences were observed between the results obtained.

The pCO_2 level of the peritoneal fluid was lower than that of the arterial blood (22.81 ± 1.18 vs. 35.87 ± 1.08 mmHg), and the HCO_3^- level of the peritoneal fluid was higher than that of the blood (30.54 ± 0.79 vs. 24.33 ± 0.42 mmol/L). These two appear to be the major factors responsible for the pH difference.

The procedure described above represents a practical method of measuring the pH of peritoneal fluid. I believe these results reflect the normal peritoneal pH range of adults, and I recommened that they be used as a reference range.

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