Duodenal Fluid pH in Cystic Fibrosis

R. E. Knauff and J. A. Adams

Attention is directed here to the major discrepancies among duodenal fluid pH measurements in cystic fibrosis. A series of 9 cystic fibrosis and 9 control subjects were found to have duodenal fluid pH values of 4.8 ± 0.7 and 6.3 ± 0.2, respectively.

There is a widespread belief that the duodenal fluid pH in cystic fibrosis is alkaline (or nearly so) and is not different from normal. This belief apparently is derived from several reports (1-4) which support such a conclusion. Shwachman and Leubner (5), however, found fibrocystic duodenal fluid usually to be acidic, sometimes markedly so.

Our observations support those of Shwachman and Leubner and conflict with the widespread acceptance of an alkaline duodenal fluid pH in cystic fibrosis.

Methods and Materials

Duodenal Samples

The duodenal samples were collected in iced containers from fasted subjects who did not receive any secretagogue or sedation. Four to six 30-min. collections were made with a 3-hole Levin tube placed by fluoroscopic verification in the second segment of the duodenum. The individual collections were frozen immediately after a pH measurement by test paper.

Measurement of pH

The individual collections of frozen duodenal fluid in 16-mm. culture tubes were thawed in the laboratory (within 72 hr.) in a shaking incubator at 37° (20 min.). Immediately after the samples were thawed, pH measurements were made potentiometrically (Beckman Zeromatic

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pH meter) and by commercial narrow-range test papers (pHydrion).* The meter and test papers were found to agree.

**Subjects**

All of the subjects were under the clinical care of a hospital physician. Accepted diagnostic criteria were used in the classification of the 10 cystic fibrosis and 9 control subjects who were from 2 months to 9 years of age.

**Results and Discussion**

The pH values of 10 cystic fibrosis samples were 2.0, 2.0, 3.5, 3.7, 5.0, 6.4, 6.6, 6.8, 6.9, and 7.7 with a mean and standard error of 5.1 ± 0.7. The pH values of 9 control samples were 4.8, 6.0, 6.2, 6.2, 6.2, 6.4, 6.7, 6.8, and 7.0 with a mean and standard error of 6.3 ± 0.2. If 1 cystic fibrosis subject with normal trypsic activity is excluded (pH 7.7), the mean becomes 4.8 ± 0.7.

These values are compared with the published literature in Table 1. It is apparent that the earlier literature, with exception of the report by Shwachman and Leubner, implies that these pH measurements are relatively too acidic. It is not obvious why major divergencies should exist.

The classic work in human and dog gastrointestinal physiology (6–8) would seem to support our values for normal human duodenal fluid. The normal fasting human or dog appears to have a continuous pH gradient of its intestinal fluids (i.e., not intestinal secretion juices) from pylorus to cecum. Average pH values for fluids in the duodenal bulb, duodenum, jejunum, and ileum seem to be 5.6, 6.4, 6.6, and 7.0, respectively. The entire small intestine is acidic; rarely are its fluids alkaline.

It is puzzling that (1) normal human duodenal fluid is reported so alkaline and (2) cystic fibrosis duodenal fluid is reported normal in pH when these subjects are known to have dysfunctional pancreatic acini—the source of pancreatic juice bicarbonate. Gibbs (1) showed that 11 of 11 cystic fibrosis subjects failed to increase their duodenal fluid titratable alkalinity in response to a dose of secretin which caused a five- to sixfold increase in controls.

In order to assess what might account for divergent pH measurements in different laboratories, 1 cystic fibrosis and 1 control duodenal fluid were placed in a refrigerator (4°C) for 48 hr. The cystic fibrosis sample changed pH from 4.9 to 6.9, and the control sample changed pH from 6.4 to 7.8. This experiment illustrates the impressive alkaline drift of pH which can occur with duodenal samples. Perhaps some labora-

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*Micro Essential Laboratory, Brooklyn, N. Y.*
DUODENAL FLUID pH

Table 1. Duodenal Fluid pH in Cystic Fibrosis

<table>
<thead>
<tr>
<th>Reference</th>
<th>Cystic Fibrosis</th>
<th>Controls</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>No. of patients</td>
<td>Mean ± S.E.</td>
</tr>
<tr>
<td>Gibbs (1)</td>
<td>11</td>
<td>6.1-8.1</td>
</tr>
<tr>
<td>Jones (2)</td>
<td>8</td>
<td>7.3-8.2</td>
</tr>
<tr>
<td>di Sant’Agnese et al. (4)</td>
<td>15</td>
<td>6.5-7.5</td>
</tr>
<tr>
<td>Shwachman and Leubner (5)</td>
<td>100</td>
<td>3.5-8.1</td>
</tr>
<tr>
<td>Knauff and Adams (this report)</td>
<td>10</td>
<td>2.0-7.7</td>
</tr>
</tbody>
</table>

* One subject with normal tryptic activity excluded.

...tories have not recognized and applied the rigid precautions necessary for accurate pH measurements of duodenal fluid.

A spot check was made in our study to evaluate if gastric hyperacidity (and leakage) was a feature of the tendency toward duodenal fluid hyperacidity in cystic fibrosis. A gastric fluid sample was secured just prior to the duodenal fluid samples in a subject. The gastric fluid had a pH of 2.5 and reflected hypoacidity, while the duodenal fluid had a pH of 5.0.

The 2 subjects who are reported to have had a duodenal fluid pH of 2.0 were also found to have had fluid this acidic on one or more earlier intubations. Good agreement was found when a given subject was scheduled for a replicate intubation. The difference between the cystic fibrosis (4.8 ± 0.7) and control (6.3 ± 0.2) subjects is significant at the p < 0.07 level.

Further studies are needed on the following to determine their effects on duodenal fluid pH: type of intubation tube, placement of tube, environmental management of subject, sedation, secretogogue, and sample manipulation.

References