HUNGER AND APPETITE SECRETION OF GASTRIC JUICE IN INFANTS’ STOMACHS*

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There is apparently a gastric element in appetite. The contractions of the stomach institute hunger. Its profuse and rich secretion causes an entirely different sensation—not painful, but pleasant. Carlson concludes that the appetite or psychic gastric juice described by Pawlow stimulate sensory nerve endings in the gastric mucosa. The resulting sensation resembles that which follows the first few mouthfuls of good food at a meal to which one has come hungry, and directs the flow of consciousness toward the matter of taking food.

Pediatric literature contains many references to this secretion. Bauer and Deutsch found no gastric juice in the baby’s stomach after it had reached eagerly for its bottle. Pfaundler noted that in babes who nursed actively the stomach emptied sooner, and the degree of acidity attained was higher than in babes who were fed passively or through the tube. Cohnheim and Soetbeer, working with gastrotomized new-born pups, obtained juice containing hydrochloric acid even when the pups nursed on nonlactating breasts. A. H. Meyer found a great variation in gastric acidities in the same child and conjectured that the variations might depend on the presence or absence of Pawlow’s appetite juice. Schmidt writes that the infant on the breast works and stimulates the secretion of gastric juice. Meisl advocates the use of a pacifier before meals to cause the flow of appetite juice. Bogen, whose material included a 3½-year-old boy with a stenosed esophagus and gastric fistula, concludes that psychic secretion of gastric juice does occur. Nothmann, in 1909, formally investigated the question of the secretion of appetite juice by the infant’s stomach, and concluded that it took place even immediately after birth. Rosenstern advised the use of pepsin and hydrochloric acid to stimulate the appetite of infants who nurse poorly. Bönniger could find in pups no relation between the kind of food and the secretion of gastric juice.

With the exceptions of the work done on pups, and Bogen’s work on a 3½-year-old boy, the foregoing is all brought into question because it relies on the use of the ordinary catheter or stiff stomach tube, which

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1. References to the literature will be found at the end of the article.
does not permit accurate quantitative studies. A still more serious criticism, and one which leaves the whole subject open, is that in none of the quoted work is the possibility of a continuous secretion of gastric juice sufficiently taken into account.

In 1888 Leo found free hydrochloric acid in the stomachs of unfed new-born babes, and noted that in older infants the stomach was rarely entirely empty, so that he could usually recover a few drops of thick, yellowish acid fluid. He washed out the stomach and again inserted the tube and then obtained only wash water from the preceding washings. Consequently Leo concluded that the acid juice obtained by him from the "empty" stomach was the gastric juice remaining from the last meal, concentrated by the absorption of water. Wohlmann reported that the secretion of the infant's empty stomach is viscid, colorless, glassy, and without free hydrochloric acid. Wohlmann took his specimens from one to two hours after feeding. The teachings of Pawlow that gastric secretion depends on appetite or on food or other stimuli in the stomach impressed the medical mind so deeply that until the present decade all gastric secretion was interpreted in the light of his investigations. A. H. Meyer concluded that the passage of the stomach tube does not excite the secretion of acid gastric juice. Pawlow's published work supports the same conclusion. Engel reports a 4-week-old babe with pyloric stenosis and a jejunal fistula. From this infant, who was fed through the fistula, Engel obtained by way of the esophagus from 60 to 200 c.c. of gastric juice daily. The total acidity of this juice ranged from 60 to 70 and was nearly entirely made up of free hydrochloric acid. Engel was unable to explain his findings except on the basis of a pathologic hypersecretion, which he thought might have caused the pyloric stenosis. Alfred F. Hess, in 1913, showed that the stomach of the unfed new-born babe secretes a highly acid juice, and he concluded further that saliva does not act as a stimulus to the production of such juice. He was unable to determine a relationship between the amount of sucking and the amount of juice secreted. Sedgwick recovered acid stomach and duodenal contents three and four hours after nursing. In 1905 Boldyreff reported continuous secretion of the gastric glands in starving dogs. Ten years later Fowler, Rehfuss and Hawk concluded that, in man, the gastric glands are never idle, while Carlson demonstrated the continuous secretion of gastric juice in the empty stomach of normal adults. Referring to its secretion during the hunger state, Carlson calls it hunger juice.

It is evident that the determination of the secretion of an appetite juice in the infant's stomach must be made in conjunction with the determination of its continuous secretion.

The flexible tube with the slotted weight at the tip described by Rehfuss, combined with any simple syringe for gentle aspiration, makes
an excellent instrument for the study of the physiology of the stomach of the infant. A smaller tip can be made for those infants who cannot swallow the ordinary tip. With this apparatus I have repeatedly recovered from the infant's stomach the entire 30 to 50 c.c. of water introduced into it and never have lost more than 2 c.c. in the washing. Furthermore, large, thick, gelatinous clumps of mucus and curd are removed without difficulty.

In order to avoid, as far as possible, contaminating the gastric juice with saliva, and to permit the carrying out of sham feeding, I converted a No. 21 F. soft rubber catheter into an outer casing for the Rehfuss tube. When in place this outer casing terminates internally in the esophagus, and externally with a suction apparatus. The whole is explained in the accompanying illustration, which is one-half actual size.

The experimental procedure was as follows: If the babe fasted all night, he was given water at 5 a.m. in quantity equivalent to his usual feeding. When the stomach was examined a few hours later, milk remains were never found. If the period without food were shorter, his stomach was thoroughly washed out and observations begun an hour later.

If no aspiration is applied to the stomach tube during the half hour, the amount obtained is usually less than 1 c.c. The usual procedure was to insert the tube, exert suction to empty the stomach of any content, then allow the tube to remain one-half hour without suction, and

![Diagram of apparatus for removing gastric contents from infants](http://archpedi.jamanetwork.com/)

Author's apparatus for removing gastric contents from infants; one-half actual size.
collect the specimen, if any. Repeat the procedure, exerting gentle suction every two and one-half minutes and collect the specimen. Exert suction in the same way during a third half hour while the sham feeding progresses. The final two specimens only are listed in the accompanying table.

As a rule, no secretion was obtained for five minutes after the insertion of the tube. On one occasion gastric juice containing free hydrochloric acid was obtained within two minutes of the time at which introduction of the tube began (Baby A.). This is less than the latent time usually required by the gastric glands (Carlson, Pawlow) and is further evidence that the secretion here obtained was not produced artificially by the apparatus.

To stimulate an appetite secretion, the babe was given a pacifier threaded over the tube, or, the food to which he was accustomed was administered by a medicine dropper, or, with the artificially fed babes, from their usual nursing bottle. The infant always sucked vigorously during this procedure. If the babe sucked before sham feeding began, it has been noted in the table. As a rule, the babes slept or were quiet and did not suck, except after the beginning of the sham feeding. The presence of the tube seemed to discommode these babes very little. There certainly was no psychic excitement to depress the action of the gastric glands while the babes were smacking and sucking over their food.

In three cases only, as noted in the table, did food reach the stomach. Strictly speaking, neither these instances nor the specimens which contained blood should be considered as offering evidence on either the subject of "hunger" or "appetite" gastric juice. The only demonstrable effect of the blood, which was never present in more than a trace, was to lower the acid titration values. On the three occasions on which milk reached the stomach, larger amounts of secretion was obtained.

The titrations were done against tenth-normal sodium hydroxid, using di-methyl-amino-azobenzol and phenolphthalein as indicators. The hydrogen-ion concentrations were done by the gas chain method. I wish to thank Dr. J. F. McClendon for his courtesy in allowing the use of his apparatus.

The "appetite" gastric juice is characterized by its relatively profuse secretion and high acidity. Neither characteristic was present in the juice obtained after sham feeding in these infants. On the contrary, the juice obtained differed little in character and quantity from that obtained before sham feeding was begun.

It will be seen that the empty stomach of the infant continuously secretes a juice which at times is as acid as that of the adult, and that the infant's stomach does not secrete an "appetite" or psychic juice.
This accords with the absence of psychic inhibition of the hunger contractions.

As indicated by the digestion of egg white in Mett's tube, the infant's hunger juice contains pepsin.

Reiche has demonstrated the absence of a duodenal reflux into the infant's stomach. The present findings support his conclusion. What, then, becomes of this continuous secretion under circumstances such as enforced therapeutic starvation from twenty-four to forty-eight hours? Pfaundler has conjectured that at the close of digestion the alkaline secretion of the pyloric glands gradually neutralizes the acid content of the stomach. I cannot support this view. The finding of a greater quantity of juice when a more continuous suction is maintained, the frequent absence of juice when the tube is first inserted, and Sedgwick's finding that the young infant's duodenal contents are acid, favor the conclusion that at least a portion of this juice makes its way into the intestine.

It seems probable, therefore, that the secretion of the alkaline pancreatic and intestinal juices, which in the adult regurgitate into the stomach, as demonstrated by Boldyreff, and lower the acidity of the juice in the stomach (Carlson, Rehfuss and Hawk and Boldyreff), is, in the infant, relatively deficient.

The hunger juice is delivered through the tube intermittently. The most profuse secretion is, as a rule, associated with the higher acidities; this is also true in the adult (Carlson). The largest amounts were obtained from one of the unfed new-born babes and from the older infants. It is readily seen that the stomach of the starving infant can secrete from 50 to 200 c.c., or more, of highly acid juice daily. This equals the amount Engel obtained from his case of pyloric stenosis, which has served as the clinical basis for the theory that hyperacidity or hypersecretion of the gastric juice is an etiologic factor in that disease.

Furthermore, this demonstration of the capacity of the infant's stomach to secrete a highly acid juice, makes it probable that the low acid values found during gastric digestion of milk are in part due to its binding power for acid (Aron), and in part due to the relatively slight stimulation which it exerts on the gastric glands (Pawlow, Moore and Allanson). Huenekens found a hydrogen ion concentration of $174 \times 10^{-9}$ in a $9\frac{1}{2}$-months-old infant after a meal of soup and vegetables. Most of his results were lower, however. No such studies have been made in younger infants.

Experience in the clinic of the University of Minnesota and in other clinics (Rott) has proved the advantage which is gained in feeding the premature infant by tube. Theoretical objections to the use of
TABLE 1.—COMPARATIVE SECRETION OF HUNGER AND APPETITE, Gastric Juice

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Length of Preceding Starvation Hours</th>
<th>Behavior During Collection of Continuous Secretion or &quot;Hunger&quot; Juice</th>
<th>Amount of &quot;Hunger&quot; Juice per ½ Hour, C.c.</th>
<th>Description of &quot;Hunger&quot; Juice</th>
<th>Method of Provoking Appetite Juice</th>
<th>Amount of Appetite Juice per ½ Hour, C.c.</th>
<th>Description of Appetite Juice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ow</td>
<td>15 hrs</td>
<td>Unfed</td>
<td>Cried; slept most of time</td>
<td>0.9</td>
<td>Slightly viscid; trace of saliva; no blood; translucent; free HCl 0; total acid 4</td>
<td>Sucking on pacifier</td>
<td>3.0</td>
<td>Thick, viscid, trace of saliva; free HCl 0; total acid 18</td>
</tr>
<tr>
<td>Wal.</td>
<td>7 days</td>
<td>4</td>
<td>Slept</td>
<td>3.0</td>
<td>Thick, viscid trace of saliva; free HCl 5; total acid 30</td>
<td>음을</td>
<td>0.5</td>
<td>Thick, viscid, trace of blood; free HCl 0; total acid 60</td>
</tr>
<tr>
<td>Wal.</td>
<td>9 days</td>
<td>6</td>
<td>Quiet; no sucking</td>
<td>3.0</td>
<td>Trace of saliva; free HCl 2.5; total acid 37.5</td>
<td>Thiol, blood stained, slightly viscid; free HCl 32; total acid 30</td>
<td>2.5</td>
<td>Brownish, blood stained, slightly viscid; free HCl 54; total acid 60</td>
</tr>
<tr>
<td>Wes.</td>
<td>2 hrs</td>
<td>Unfed</td>
<td>No sucking</td>
<td>6.0</td>
<td>CH⁺ = 0.3 x 10⁻²; free HCl 50; total acid 60</td>
<td>Clear, visible; trace of blood; free HCl 18; total acid 59</td>
<td>1.0</td>
<td>Thin, transparent, slightly viscid; free HCl 60; total acid 59</td>
</tr>
<tr>
<td>Wes.</td>
<td>7 days</td>
<td>13</td>
<td>No sucking</td>
<td>1.75</td>
<td>Yellowish, clear, viscid; Gmelin test neg.; free HCl 18; total acid 39</td>
<td>Clear, visible; trace of blood; free HCl 10; total acid 40</td>
<td>1.0</td>
<td>Clear, visible; trace of saliva; small amount of milk; free HCl 0</td>
</tr>
<tr>
<td>He.</td>
<td>6 days</td>
<td>11</td>
<td>Slept throughout; sucked a little</td>
<td>1.0</td>
<td>Slightly viscid; no saliva; no blood; free HCl 5; total acid 60</td>
<td>Clear, visible; trace of blood; free HCl 10; total acid 40</td>
<td>0.5</td>
<td>Contains 0.5 c.c. milk clot; free HCl 10; total acid 45</td>
</tr>
<tr>
<td>P.</td>
<td>9 days</td>
<td>12</td>
<td>Slept; no sucking</td>
<td>1.0</td>
<td>Clear, slightly viscid; free HCl 50; total acid 75</td>
<td>Clear, slightly viscid; trace of blood; free HCl 30; total acid 60</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>A.</td>
<td>11 days</td>
<td>12</td>
<td>Slept most of time; no sucking</td>
<td>1.5</td>
<td>Slightly viscid trace of blood; free HCl 60; total acid 80</td>
<td>5 c.c. breast milk; sucked vigorously for 15 minutes</td>
<td>1.0</td>
<td>Clear, visible; trace of blood; free HCl 10; total acid 40</td>
</tr>
<tr>
<td>S.</td>
<td>12 days</td>
<td>13</td>
<td>Cried; no sucking</td>
<td>2.0</td>
<td>Transparent, slightly viscid; free HCl 50; total acid 75</td>
<td>5 c.c. breast milk; sucked vigorously for 15 minutes</td>
<td>2.0</td>
<td>Clear, visible; trace of blood; free HCl 10; total acid 40</td>
</tr>
<tr>
<td>H.</td>
<td>17 days</td>
<td>13</td>
<td>Slept most of time; sucked occasionally</td>
<td>2.0</td>
<td>Clear, slightly viscid; trace of blood; free HCl 30; total acid 60</td>
<td>10 c.c. breast milk; sucked on tube</td>
<td>2.5</td>
<td>Brownish, blood stained, slightly viscid; free HCl 54; total acid 60</td>
</tr>
<tr>
<td>K.</td>
<td>3.5 mos.</td>
<td>17</td>
<td>Sucked on tube</td>
<td>3.5</td>
<td>Translucent viscid; trace of saliva; free HCl 7; total acid 28</td>
<td>5 c.c. woman's milk + saccharose; sucked</td>
<td>10.0</td>
<td>Clear, visible; trace of saliva; small amount of milk; free HCl 0</td>
</tr>
<tr>
<td>K.</td>
<td>3.5 mos.</td>
<td>17</td>
<td>Sucked constantly</td>
<td>3.0</td>
<td>Trace of saliva; free HCl 33; total acid 36</td>
<td>Cow's milk + saccharose; sucked</td>
<td>2.0</td>
<td>Clear, visible; trace of saliva; small amount of milk; free HCl 0</td>
</tr>
<tr>
<td>Ad.</td>
<td>5 mos.</td>
<td>16</td>
<td>Slept; no sucking</td>
<td>3.0</td>
<td>Clear, slightly viscid; trace of saliva; free HCl 50; total acid 70</td>
<td>Malt soup</td>
<td>8.0</td>
<td>Contained milk; free HCl 18; total acid 45</td>
</tr>
<tr>
<td>Ad.</td>
<td>5 mos.</td>
<td>17</td>
<td>Slept; no sucking</td>
<td>3.0</td>
<td>Clear, slightly viscid; trace of blood; free HCl 30; total acid 40</td>
<td>15 c.c. malt soup; sucked vigorously 20 minutes</td>
<td>0.2</td>
<td>Clear mucus; free HCl 0</td>
</tr>
<tr>
<td>Wi.</td>
<td>7 days</td>
<td>25</td>
<td>Cried much; did not suck</td>
<td>1.0</td>
<td>Clear, slightly viscid; trace of blood; free HCl 10; total acid 40</td>
<td>Sham feeding: 10 c.c. breast milk; sucked vigorously; quiet</td>
<td>0.9</td>
<td>Turbid, viscid, containing partially digested blood; free HCl 25; total acid 56</td>
</tr>
<tr>
<td>Ca.</td>
<td>9 days</td>
<td>24</td>
<td>Slept throughout; did not suck</td>
<td>3.0</td>
<td>Turbid, viscid fluid containing trace of blood; free HCl 12; total acid 23</td>
<td>Sham feeding: 10 c.c. breast milk; sucked vigorously; did not cry</td>
<td>1.0</td>
<td>Turbid, viscid, mucus; free HCl 0; total acid 10</td>
</tr>
<tr>
<td>Ni.</td>
<td>11 days</td>
<td>22</td>
<td>Cried ¼ of time; sucked a little</td>
<td>1.5</td>
<td>Viscid mucus; free HCl 0; total acid 8</td>
<td>Sham feeding: 10 c.c. breast milk; sucked vigorously; did not cry</td>
<td>1.0</td>
<td>Visicd mucus; trace of blood; free HCl 10; total acid 16</td>
</tr>
</tbody>
</table>
the tube have been based principally on the assumed existence of an appetite gastric juice (Pfaundler).

The amount of saliva collected during the experiments on gastric secretion was measured in six cases.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Amount</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>W.</td>
<td>7 days.</td>
<td>No sham feeding</td>
<td>7 c.c. in 40 minutes</td>
</tr>
<tr>
<td>H.</td>
<td>17 days.</td>
<td>Sham feeding</td>
<td>14 c.c. in 2 hours</td>
</tr>
<tr>
<td>P.</td>
<td>1 mo.</td>
<td>Sham feeding</td>
<td>25 c.c. in 1.5 hours</td>
</tr>
<tr>
<td>Ne.</td>
<td>11 days.</td>
<td>Sham feeding</td>
<td>15 c.c. in 1.5 hours</td>
</tr>
<tr>
<td>P.</td>
<td>9 days.</td>
<td>Sham feeding</td>
<td>8 c.c. in 1.5 hours</td>
</tr>
<tr>
<td>S.</td>
<td>12 days.</td>
<td>Sham feeding</td>
<td>10 c.c. in 1.5 hours</td>
</tr>
</tbody>
</table>

The saliva collected was the thick viscid product of the submaxillary glands, which Schilling has noted as being preponderant during early infancy.

Allaria points out the chemical and mechanical advantages of having the milk well mixed with saliva, and estimates that the infant secretes an amount equal to from 10 to 20 per cent. of the ingested food. The tube-fed infant may do without this secretion in part or altogether, but there is no evidence that his gastric secretion is less than that of the actively nursing babe.

What light does this study throw on deprivation of food as a therapeutic agent? In infancy such a measure finds its chief field in acute alimentary disorders and summer diarrheas. The significant fact is that in hunger the infant's stomach secretes continuously, but with intermittent intensity, a highly acid juice, which at least in part flows into the small intestine where it may play a disinfecting or detoxicating rôle.

SUMMARY

1. Description of an apparatus by which sham feeding can be carried out and gastric juice collected under conditions which give positive evidence of the amount secreted.

2. There is no appetite or psychic secretion of gastric juice in the young infant. This disproves the present view, which is based on insufficient experimental evidence.

3. The empty stomach of the hungry babe secretes a gastric juice which often is as acid as that found in the adult's stomach.

4. The more profuse this secretion, the higher is its acidity. It contains pepsin.

5. This secretion is not neutralized in the stomach, but flows out into the small intestine. Regurgitation through the infant's pylorus does not occur.

6. The theoretical objections to tube feeding in prematures because of the lack of stimulation of an appetite gastric juice are not valid. However, a disadvantage may lie in this: that such feeding precludes the usual admixture of the milk with saliva.
Therapeutic starvation in acute alimentary disorders and in summer diarrheas may owe its success in part to the heightened tone of the alimentary tract, and in part to the pouring out of highly acid detoxicating and disinfecting gastric juice into the small intestine.

I wish to acknowledge my indebtedness to Dr. J. P. Sedgwick for the use of material from his service in the University of Minnesota Hospital.

REFERENCES


