Effect of Air-Craft Noise on Gastric Function

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ABSTRACT

Thirty three healthy young men and six dogs equipped with gastric fistulae were stimulated by noise of 100 to 120 phon emanating from a F-86F jet engine. The basal secretion of gastric juice in the dogs was little changed, but in human subjects the secretion of gastric juice was altered as follows; 30.3% of 33 subjects showed an increased acid output, 63.6% showed a decrease and the remaining showed no change. Furthermore, the basal resting secretion of those showing decreased acidity from noise exposure was higher than that of those showing increased acidity. Gastric motility was greatly inhibited by exposure to noise in both dogs and humans but the inhibition was more sensitive and more prolonged in humans.

Rats fed synthetic diet were placed under conditions of repeated noise for either short or long periods and the occurrence of gastric ulcers by the procedure described by Shay et al was observed. The prevalence of ulcer lesions was increased and the severity of the lesion was enhanced in rats exposed to noise for either short or long periods.

The above results indicate that the influences of air-craft noise were not remarkable, but the noise to a considerable degree, is responsible for the occurrence of gastric disorders in man.

Sound fields surrounding air-craft engines are thought to be the cause of physical or mental disturbances experienced by persons at close range. Laird (1932) reported that 60 decibels of noise decreased the normal secretion of gastric juice in four of five human subjects who previously had been given an Ewald meal and also caused a decrease in the normal secretion of saliva by about 40 per cent. Previously Laird and Smith (1930) had observed that 80 to 90 decibels of noise caused a decrease in gastric motility in human beings. Vaughn and Van Liere (1940) reported a significant reduction in acid secretion in dogs with Pavlov pouches from a noise of 100 decibels and 2,000 frequency. However, noise frequency of 600 was ineffective.

The present study was undertaken to determine in humans and animals whether digestive function or other disorders occurred readily with either single or repeated exposure to air-craft noise.

METHODS

Thirty three healthy Korean males, 54 to 70 kg in weight, 163 to 178 cm in height and 21 to 31 in age were employed in this experiment. Gastric juice collections were performed in the early morning with all subjects in the fasting condition. In animal experiments, six mongrel dogs weighing 10 to 15 kg and albino rats weighing about 200 g were used. In four dogs denervated Heidenhain pouches were prepared by the technique described by Devito and Harkins (1959). In two dogs stomach canulae were simply fixed in the fundic portion without interruption of nerve supply (Fig.1). These dogs were maintained carefully until complete healing of the surgical wound. They were unfed for 15 hours before each experiment and the collections were performed in the conscious state. Rats fed a synthetic diet were placed under the conditions of repeated noise for either short or long periods and gastric ulcers were produced by the procedure described by Shay et al.
Effect of Air-Craft Noise on Gastric Function (1945).

Fasting gastric juice was collected in 15 min intervals, before and after exposure to noise in humans and dogs. In dogs the response of a meal (500 g) and histamine (2 mg base) were also determined. The free and total acidity of the gastric juice was measured in 1.0 ml aliquots by titration of the sample with N/20 NaOH, using Töpférm's reagent and phenolphthalein as indicators.

Mucin content and pepsin were determined by biuret reaction and Anson's method (1939), respectively. Fasting gastric motility was determined with water pressure after a tube with an attached balloon was passed through a gastric fistula in the dog and through the mouth in man. The changes in water pressure were traced on kymographic paper by means of a tambour.

Source of noise: A F-86F jet engine sound was recorded at a distance of 3 m from the engine pipe during an engine test. The sound was reproduced through an amplifying Hi-Fi with a speaker, which emitted 100 to 120 phons of noise. The noise was measured by a noise meter. The background noise showed about 20

![Fig. 1. Dog with a gastric fistula (A) and Heidenhain pouch (B)](image1)

![Fig. 2. Effect of noise on acid secretion from fasting human stomach](image2)  
(a) Basal resting secretion is increased by noise exposure

![Fig. 2. b) Basal resting secretion is decreased by noise exposure](image3)

![Fig. 3. Effect of noise on gastric motility in dog. The peristaltic movement is inhibited by noise and recovered by the withdrawal. Atropine inhibits the motility.](image4)
Table 1. Gastric secretion during course of exposure to jet engine noise in human

<table>
<thead>
<tr>
<th>No. of</th>
<th>Gastric response at 15 min interval*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
</tr>
<tr>
<td>Volume, ml</td>
<td>33</td>
</tr>
<tr>
<td>Protein content, mg/100ml</td>
<td>33</td>
</tr>
<tr>
<td>Acidity, mEq/l</td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td></td>
</tr>
<tr>
<td>Free</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>37.0±4.0</td>
</tr>
<tr>
<td>Group B</td>
<td></td>
</tr>
<tr>
<td>Free</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>62.8±5.6</td>
</tr>
</tbody>
</table>

* Values are Mean±S.E.
+ indicates noise exposure.

In this experiment. The subjects were exposed to noise for 30 min to 60 min in cases of the human and dog experiments and to repeating noise for 60 min in rats.

RESULTS

In the Heidenhain pouch dogs a meal (500g) stimulated the production of gastric juice. The secretion lasted about 3 hours with the peak of secretion being reached in 60 to 120 min after feeding. Following the subcutaneous administration of histamine, in either Heidenhain pouch or simple pouch dogs the peak of the gastric secretion was observed in the 30 to 60 min after feeding. After 2 hours there was a negligible output of secretion. Following the exposure to the noise (100-120 phons) the basal secretion of gastric juice was little changed and showed only a slight increase of secretion in gastric or Heidenhain pouch dogs.

In 33 human subjects the resting flow and free acid content of gastric juice were 2.09ml/min and 34.2 mEq/1. Following exposure to noise the flow of gastric juice was slightly decreased and continued for 60min even after withdrawal of the noise. The overall average acidity and mucin content of gastric juice were not altered by noise. Nevertheless, the subjects can divided into 2 categories, e.g., those decreased and those increased as to acid output of gastric juice by the influence of noise. The former was 30.3% and the latter was 63.6% out of the total subjects. No change was seen in 2 subjects. It is noticed that the basal secretion of those showing decreased acidity was quite high and of those with increased acidity was low (Table 1 & Figure 2).

The active and regular fasting gastric peristaltic movement was greatly inhibited by the exposure to noise in total gastric pouch dogs (Fig. 2). Withdrawal of the noise resulted in rapid recovery of movement with a slight initial enhancement. The gastric movement was completely inhibited by atropine. The inhibition of gastric movement by noise in human subjects was more sensitive and more prolonged than that of dogs.

Ulcerative gastric lesions in rats were produced by the procedure of Shay et al (1945), followed by exposure to noise. Two groups were devised by receiving short or long term exposure to noise. The occurrence of ulcer lesions increased and the severity of the lesions was enhanced in groups receiving noise for either short or long period (Table 2). The majority of the rats...
Table 2. Influence of noise on experimentally-induced gastric ulcer in rats

<table>
<thead>
<tr>
<th>Group</th>
<th>Starved (hr)</th>
<th>Ligated (hr)</th>
<th>Treated</th>
<th>No. of rats used</th>
<th>No. of rats had ulcer</th>
<th>Ulcer incidence %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Degree of ulcer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1⁺</td>
<td>2⁺</td>
</tr>
<tr>
<td>Short-term</td>
<td>24</td>
<td>20</td>
<td>Control</td>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Noise</td>
<td>8</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Long-term</td>
<td>24</td>
<td>20</td>
<td>Control</td>
<td>10</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Noise</td>
<td>14</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

* 1⁺: slight, 2⁺: moderate, 3⁺: severe, and 4⁺: the most severe degree of ulcer.

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**DISCUSSION**

It is generally conceded that there is no clearcut evidence nor explanation for gastrointestinal disorders in individuals who are obliged to expose to noises. According to Finkle and Poppen (1948) the experimental data derived from 10 volunteers exposed to turbo-jet engine noise for a total of 20 hrs over a period of 6 weeks revealed the following: a) Increase in fatigue and irritability during the entire course of the experiment in 7 of the 10 subjects. b) Early, temporary, sharp decrease in auditory acuity in the conversational frequency range of 512 to 4096 cycle per second. Normal hearing was gradually regained by the 7 subjects affected within 12 hrs or less after onset. c) Loss in

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**Fig. 4.**

- Effect of noise on gastric motility in human.
  - a) The gastric motility is inhibited by the noise and the effect is continued for more than 30 min after the withdrawal.
  - b) The inhibition of gastric motility is less than the above subject.
weight of 5.5 to 19 pounds in 5 of 9 subjects, however, it is questionable that this finding is a result of the experiment. d) Rise in fasting blood sugar during a one-hour period of exposure to the jet engine in all subjects and decrease is the fasting blood sugar level after a two-hour exposure in 7 of the 10 test subjects. e) Normal findings, unchanged from pre-experimental values, where noted for blood counts, urinalysis, kidney function tests, bleeding and clotting times, icteric indices, upper gastrointestinal x-ray studies, electrocardiograms and electroencephalograms during and after the experiment. Though the studies of noise effects on human subjects were extensive, they did not attempt to study gastrointestinal function except for a gross fluoroscopic or X-ray check.

The purpose of the experiments undertaken in this study was to provide some pertinent information on gastrointestinal responses to noise emanating from a jet airplane engine. In gastric or Heidenhain pouch dogs the fasting basal secretion of gastric juice was not changed by the exposure to jet engine noise in our experiment. Vaughan and Van Liere (1940) found that only one out of 4 dogs at a frequency of 6000 cycles with 100 decibels showed a significant reduction in the volume of gastric juice secreted, none showed a significant reduction in the amount of acid secreted and neither volume nor acid in the four dogs was significantly affected in the average. These results imply that the intensity of the noise applied in our experiment was not sufficient to alter the secretion from the canine stomach. Nevertheless, in human subjects the secretion of gastric juice was considerably changed by the exposure to noise, e.g., 30.3% of the total 33 human subjects showed increased acid output and 63.6% showed the decrease. Furthermore, it is interesting to note that the basal resting secretion of those showing decreased acidity from noise exposure was considerably higher than that of those showing increased acidity. This indicates that the general behaviour of man exposed to noise, especially to disagreeable noise, shows that different persons (or even the same person under different situations) responds quite differently, quantitatively and qualitatively, to the same noise (Lehmann, 1964).

Hale (1952) mentioned in his abstract that observers, who were either accustomed or unaccustomed to intense noise, at an aircraft testing stand or a less-noisy engine assembly line, showed a pattern of change of a mild degree of stress reaction. Arguelles et al (1962) observed that sound frequency of 125 to 10,000 cycles per second with intensities of 65 to 93 decibels exerted substantial elevations in the free plasma 17-hydroxycorticoids and urinary 17-ketogenic steroid in normal subjects. They also noted that striking elevations in the plasma steroid levels were observed in psychoneurotic patients with anxiety, but there was elevation in depressive cases and they concluded that adrenal cortical function in man may be remarkably sensitive to auditory stimulation, probably through the effect of ACTH released by intense sound. Laird (1932) reported that the meal (Ewald) response of gastric secretion was decreased by 60 decibels of noise in 4 of 5 human subjects and the secretion of saliva was decreased by about 40%. Earlier, in the ingenious studies of Beaumont (1833) on a human subject whose stomach could be inspected through a fistula, gastric secretion was reduced subnormal for several months when the dominant psychotic state was self-reproach. However, increased secretion was found to accompany aggressive actions. The same fistula subject, when unjustly reproached, experienced strong feelings of hostility; at the same time, both acid secretion and mucosal blood flow increased about 25% and remained elevated for 2 weeks. The generalization derived from the above
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studies is that, according to Davenport (1966), when the affective state is one of fear, sadness or withdrawal, gastric secretion is reduced, but when the dominant element is aggressiveness or the will to fight back, gastric secretion increases. Our results of gastric secretion in response to noise, in part, might correspond with the individual emotional state in the particular situation when the investigation was performed as was noted by Beaumont. Nevertheless, it is more likely that the alteration of gastric secretion by noise may be brought through the mediation of the hypophyseal adrenocortical system, which is remarkably sensitive to auditory stimuli according to Arguelles et al (1962).

In our experiment the occurrence of ulcer lesions was increased and the severity of the lesion was enhanced by exposure to noise for either short or long periods in rats receiving pyloric ligation and starvation by the procedure of Shay et al (1945). This result is understandable since the reaction caused by various stimuli may amply affect the gastric mucosa (French et al, 1957).

Formerly, Cannon (1929) noted the effect of fright or sudden loud noises in halting the peristaltic contractions of the stomach of animals. Laird and Smith (1930) showed that noise of the 3-A audiometer at a level of 60 decibels inhibited the peristaltic activity of the stomach. In our experiment active and regular fasting peristaltic movement was greatly inhibited by exposure to noise and the inhibition was more sensitive and more prolonged in human subjects. It is felt that the effect is more related sympathetic discharge in response to intense noise. This fact, together with the alteration in human gastric secretion from noises, indicates that noise to a considerable degree is responsible for the occurrence of gastric disorders in human.

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REFERENCES