A STUDY OF THE SENSORY AREAS ELICITING THE SWALLOWING REFLEX

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Since the introduction of the use of iodized oil by Sicard and Forestier in 1922 (1) in clinical medicine, extensive use has been made of this radio-opaque substance in accurately outlining the bronchial tree in the roentgenographic diagnosis of certain bronchopulmonic lesions. A number of different methods have been described and are in common use for the administration of this iodized oil, but perhaps one of the most satisfactory methods, because it obviates the use of the bronchoscope and other intratracheal instruments, is the one (2) by which the oil is allowed to descend supraglottically into the trachea, aided by gravity and aspiration, after the widespread application of cocaine to the pharyngeal regions.

The well-known demonstration of the reflex character of the deglutary act and its dependence on afferent impulses from different areas in the mouth and pharynx by Wassilieff (3) naturally suggests that the administration of cocaine to the pharyngeal regions in the administration of lipiodal owes its effectiveness to the depression or elimination of the swallowing reflex, and that this has been brought about by the paralysis of the sensory areas in the natural food passages. The considerable impetus that has been given to the use of iodized oil in studies of pulmonary diseases by the supraglottic method, has therefore aroused the question if there might not be a specific area, or a few limited areas, stimulation of which alone is uniformly responsible for inducing the swallowing reflex.

A study undertaken to determine the relative ease with which the swallowing reflex is elicited from the various regions in the throat of man should possess not only general physiological interest but clinical significance as well. Should specific areas be found which are always responsible for the initiation of the swallowing reflex, the amount of cocainization could be greatly reduced. This would be a very desirable thing in view of the not infrequent occurrence of cocaine intoxication following the application of this drug to mucous surfaces. We wish to thank Dr. A. J. Ochsner, now of Tulane University, for suggesting this problem.

As far as known no detailed observations on man have been made with reference to the most sensitive sites in the throat for inducing the swallow-
ing reflex. In 1888 Wassilieff (3) was unable to find on himself a single area which if stimulated alone would invariably elicit the swallowing reflex, but he did succeed in entirely abolishing the reflex by swallowing a sponge saturated with a solution of cocaine and then withdrawing it with a string.

Studies have been made on a number of species of mammals in attempts to determine precise areas in the pharyngeal regions at which the afferent impulses originate, and the stimulation of which is most effective in initiating the swallowing reflex. Thus, according to Kahn (4), in the rabbit the most sensitive area in this respect is the soft palate in the region between the posterior portion of the hard palate and the tonsils. In the dog the chief sensory area appears to be located on the posterior pharyngeal wall. The same is true in the case of the cat. It is of interest with reference to what is to follow in this paper that Kahn found that in monkeys the chief area is along the palatine arch in the region of the tonsils.

EXPERIMENTAL. In the present study one hundred and twenty-six students at the University of Wisconsin were used as subjects. These were informed as to the purpose and nature of the experiments and their cooperation secured. Different areas of their throats were stimulated by the light application of blunt glass rods; with fine jets of water directed against localized areas; or with the direct application of faradic stimuli. After many trials the latter two methods were discarded. It was difficult to attribute a specific effect to the jets of water because it was impossible to keep water in definitely restricted areas. The faradic method of stimulation was objectionable because of the difficulty in separating the mechanical from the electrical effect, and because of the pain produced by this form of stimulation.

The subjects were instructed to swallow only when caused to do so in response to the stimulus, but not to inhibit the impulse to swallow. Various areas in the throats were stimulated, first by the application of a light touch with the glass rod to a single area. Then if no reflex occurred the rod was moved back and forth over a slightly larger area, more pressure being applied so as to stimulate more successive spots. When the application of the stimulus to any given area initiated the deglutory reflex a record of this fact was made on a separate mimeographed sheet containing a diagram of the accessible pharyngeal regions. The relative ease with which different areas responded to stimulation, or the failure of an area to respond, was noted in every case and appropriate individual records kept. It was found that there is very great variation in different individuals with respect to the ease with which the reflex can be started. These variations ranged all the way between those cases in which even the slightest or gentlest pressure applied to a given area in the pharynx would cause unmistakable swallowing movements, to those cases in which the throats
were normally so insensitive that they would endure considerable mechanical irritation, even to the extent that locking hemostatic forceps into them caused no marked effect as far as pain or the swallowing reflex was concerned.

Compilation of the data showed that there is apparently no single area which will in all individuals invariably cause the swallowing reflex when mechanically stimulated. Great variations were also found to exist in

Fig. 1. Showing the effect of stimulating different areas in the pharynx.

The plus (+) sign indicates a swallowing reflex in response to a light stimulus over a small area. The double plus (++) sign indicates a swallowing reflex which occurred only in response to a stronger stimulation over a larger area. The minus sign (−) indicates no response. The figures represent percentages.

the different areas with regard to their susceptibility in causing swallowing in different individuals. The results of this study on 126 individuals are summarized in figure 1. In spite of the variations just mentioned, one thing of great importance brought out by this experiment is that of all the regions studied, the pillars, particularly the anterior, are most sensitive,
and the soft palate and uvula least sensitive. The posterior wall of the
pharynx was found to be able to arouse the reflex upon stimulation in
about the same percentage as the anterior pillars, a stronger stimulus
however being required. In 77 per cent of the individuals it was possible
to initiate the swallowing reflex by the stimulation of the anterior pillars.
That only 23 per cent of the cases which failed to respond upon stimula-
tion of this area, as opposed to the 80.8 per cent and 68 per cent failures
to respond when the soft palate and the uvula respectively were stimulated,
is regarded as evidence that the anterior pillars of the fauces bear a more
important relationship to the swallowing mechanism. One might have
expected that the sinus tonsillaris would yield a larger percentage of
positive reactions because of its proximity to the anterior and posterior
pillars than was found to be the case. A possible explanation for this
fact is that due to scar tissue formation following tonsillectomy, in a large
number of cases, this area became less sensitive to mechanical stimu-
lation.

The study was extended to determine, if possible, the effect of painting
different limited areas in and about the pharynx with cocaine. Seventy-
two different individuals were used in these tests. Of these seventy-two
individuals, twenty-four persons were given two or more applications of
cocaine hydrochloride which was always used in amounts of 2 cc. of a 10
per cent solution. A total number of one hundred sixty-five applications
was made. In a considerable number of cases 1:1000 adrenalin chloride
was added to the cocaine solution in the proportion of one drop to 10 cc.
to localize further the anesthetized area which was being painted with a
small brush or cotton swab. Even by taking this precaution, it was
possible that, because of untimely swallowing or gagging, some of the
cocaine produced its effect beyond the original site of application. Where
this was known to have occurred the data for that particular case were
discarded. The resultant impediment in swallowing, chiefly evidenced
by difficulty in raising the thyroid cartilage, and by subjective symptoms,
was noted. Those individuals who received more than one application of
cocaine were asked to make a mental note to the degree of difficulty they
had encountered in swallowing with each application and were asked to
compare the effects in each case. Compilation of the records furnished
the data for table 1.

Without exception, in these individuals, the application of cocaine to
the anterior pillars caused a definite impairment to swallowing. Nine
of the forty-nine individuals whose anterior pillars had been cocainized
found it impossible to swallow when these regions were stimulated until
after the effects of the cocaine had worn off. Twenty individuals of this
group suffered marked impairment to the reflex and found it all but im-
possible to voluntarily swallow. It is significant that the swallowing
reflex was completely abolished only in that group of individuals whose anterior pillars had been painted.

Cocainization of the posterior pillars was effective in 54.5 per cent of the cases in impairing the swallowing act. Inspection of table 1 shows that the extent of the effect when this area was cocainized was noticeably less than was the case of the anterior pillars.

That the uvula and soft palate apparently bear little relation to the swallowing mechanism is evidenced by the fact that only in about 14 per cent of the cases did cocainization of this area interfere with the swallowing act. That the percentage in this particular case is as high as it is may perhaps be due to the fact that some of the cocaine, instead of exerting its effect at the site of its original application alone, ran down over the very sensitive anterior pillars and produced its effect there.

When the sinus tonsillaris was cocainized there was a resultant impairment in swallowing in eighteen of the nineteen cases. However, the degree of impairment was noticeably less than in the cases of the pillars. How much of the effect produced by the cocaine in this general area could be attributed to the spreading of the drug to the neighboring pillars is, of course, difficult to say.

Cocainization of the posterior wall of the pharynx and of the base of the tongue was relatively ineffective as far as impairment of the swallowing reflex is concerned. Two individuals whose posterior wall of the pharynx had been cocainized suffered a moderate impairment to swallowing, but cocainization was entirely without effect in 63 per cent of the cases. Cocainization of the base of the tongue was without effect in 73 per cent of the cases, the remaining 27 per cent showing only a mild impairment to swallowing.

### Table 1

*Showing the effects of the application of cocaine to different areas in the pharynx*

<table>
<thead>
<tr>
<th>AREA PAINTED</th>
<th>-</th>
<th>+</th>
<th>++</th>
<th>+++</th>
<th>++++</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior pillars</td>
<td>0</td>
<td>9</td>
<td>11</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>Posterior pillars</td>
<td>13</td>
<td>9</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Uvula and soft palate</td>
<td>19</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sinus tonsillaris</td>
<td>1</td>
<td>13</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Posterior wall of pharynx</td>
<td>17</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Base of tongue</td>
<td>11</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

However, the degree of impairment was noticeably less than in the cases of the pillars. How much of the effect produced by the cocaine in this general area could be attributed to the spreading of the drug to the neighboring pillars is, of course, difficult to say.
SUMMARY

From the data presented it appears that the areas in the pharynx mechanical stimulation of which will initiate the swallowing reflex vary considerably in different individuals, and that to no single area can be ascribed the exclusive power of causing the swallowing act. The anterior pillars of the fauces, however, appear to be notably effective in instituting the swallowing reflex as evidenced by the fact that a larger percentage of individuals responded to a light stimulus to this area than to any other area studied. The posterior pharynx and the posterior pillars were next in order of sensitiveness. The uvula and soft palate were found to be relatively very insensitive as far as initiating the swallowing reflex is concerned.

Cocainization of different areas in the pharynx bears out the above conclusions and shows that the anterior pillars of the fauces are particularly sensitive to the effects of the drug as far as impairment of the swallowing act is concerned. The posterior pillars and the sinus tonsillaris are also noticeably affected by cocaine but to a lesser extent than the anterior pillars. There is very little impairment to swallowing when the uvula, soft palate, and the base of the tongue and posterior wall of pharynx are cocainized.

BIBLIOGRAPHY

(4) Kahn, R. Arch. f. Physiol., 1903, 386.