

Taste and Health: New Frontiers in Oral Physiology and Rehabilitation

Physiological Significance of Taste on Ingestion and Swallowing

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Due to an increasing incidence of stroke as well as a growing population of elderly individuals, the number of bedridden persons in Japan is increasing. Since their muscle and nervous system for oral functions may be lowered, many of them are suffered with difficulty in swallowing (dysphasia). In cases of severe swallowing disorders, patients may aspirate their food, in which bacteria carried with the food into the airway might cause a critical condition such as pneumonia. Tube feeding is one way to bypass the pharynx, and avoid the aspiration of food. However, tube feeding deprives patients of the pleasure associated with eating. Most patients want to take food through the mouth; thus methods need to be developed that address difficulties in swallowing. Mastication have been understood being a process to crush and mix with saliva for safe swallow; however, in addition to it humans sense the physical and chemical (*i.e.*, taste) properties of food during mastication so that we secure security of the appetite. Swallowing is a reflex during which many muscles are activated in given timings to move food and/or liquid from the oral cavity to the stomach. Since affection system may strongly interpose in the swallowing process, a good appetite may be the most important factor for a smooth swallowing process. Properties required for the food include: clear taste, proper temperature, uniformity, agglutination, and moisture.

Key words — taste, mastication, swallowing, food recognition

INTRODUCTION

Due to an increasing incidence of stroke as well as a growing population of elderly individuals, the number of bedridden persons in Japan is increasing. Since their muscle and nervous system for oral functions may be lowered, many of them are suffered with difficulty in swallowing (dysphasia). In cases of severe swallowing disorders, patients may aspirate their food. Tube feeding is one way to bypass the pharynx, and avoid the aspiration of food. However, tube feeding deprives patients of the plea-

sure associated with eating. Most patients want to take food through the mouth; thus methods need to be developed that address difficulties in swallowing. Therefore, I shall overview the swallowing function from the physiological point of view.

Ingestion of food is driven by hunger. Humans first examine food by sight and smell (recognition of food). During the recognition process, sweet, salt and Umami tastes are used to evaluate food value, and bitter and sour tastes indicate potential hazards. However, this is not applicable to human behaviors, in that humans enjoy bitter or sour tastes. Once the food is determined to be safe or preferred, it is taken into the mouth. In the case of solid food, the front teeth bite off a certain volume of food.¹⁾ Then, the tongue compresses the food against the hard palate so that the mechanical properties of the food can be evaluated. If the food is soft, like pudding, or fine, like 'Tofu,' it may be compressed between the tongue and palate during this process.²⁾ If the brain

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determines that the hardness of the food requires mastication, the tongue carries the food to the back teeth (Stage I transport of food). Mechanical and chemical characteristics of the food are again evaluated in the mouth during the masticatory process, and safety and preferences are reconfirmed. During mastication, mechanoreceptors and chemoreceptors (taste receptors) evaluate the characteristics of food, and then the brain evaluates if the food is the same food as expected after the recognition process of sight and smell.

During the masticatory process, food is turned into the so-called food bolus. The bolus is then forwarded by the tongue toward the pharynx (Stage II transport). Saliva is essential in forming the food bolus and is important for smooth swallowing.

Swallowing is a reflex during which many muscles are activated in given timings to move food and/or liquid from the oral cavity to the stomach. Swallowing has been explained as complex behaviors with three stages; *i.e.*, oral, pharyngeal and esophageal stages. A complex motor program composed of two components exists in the brain stem: one component triggers the swallowing sequence and the other component activates individual motor neurons according to a programmed sequence in the neural circuits. The initiation of swallowing takes place in two regions, cerebral cortex and the peripheral sensory system. The initiation of swallowing may be affected by dysfunctions in the central nervous system, such as those that occur following a stroke.

When a certain amount of food is chewed and mixed with saliva, the tongue pushes the bolus toward the pharynx and swallowing is elicited (Oral stage of swallowing). As has been described above, some of the food bolus is already stay in the pharynx. Thereafter, swallow carries both food bolus in the mouth and pharynx towards the stomach.

Then the food bolus passes through the pharynx (Pharyngeal stage of swallowing). The pharynx, composed of many muscles, and has two inputs and two outputs for air and food. Air comes into the pharynx through the nasal cavity, and proceeds to the lungs through the laryngeal aditus. On the other hand, food comes into the pharynx through the fauces, and proceeds to the stomach through the esophagus. Swallowing may be explained as a switching function of the pharynx for the air way and the food way. There are few problems with passing air through the pharynx; however, the construction of the pharynx is too complex for food to

pass through safely. Laryngeal aditus opens widely as if it inveigle into the air way. Therefore, if there is a problem with the swallowing process, food may enter the larynx by mistake.

When the pharyngeal stage of swallowing is completed, the food bolus is then moved via peristalsis into the esophagus and toward the stomach (Esophageal stage of swallowing).

If the food bolus accidentally enters the larynx, it may elicit a cough reflex, which is often enough to clear the food from the airway. If the food remains in the larynx (*e.g.*, aspiration), bacteria carried with the food into the airway might cause a critical condition such as pneumonia. Even if these problems do not occur, patients feel a sensation of choking and often experience pain. If difficulties in swallowing continue to occur, patients tend to avoid meals. For these patients, the smoothness of the swallowing process is important. In addition to a good appetite, which is the most important factor for eating, properties of food that are needed for a smooth swallowing process include: clear taste, proper temperature, uniformity, agglutination, and moisture. In addition, the environment of the meal, such as posture of the patient, routine of feeding process should be considered.

To elicit a smooth swallowing process, both the motor control system and the sensory system are essential. Patients with dysphasia can swallow a favorite food with less risk of aspiration. Our study using Magneto-encephalogram³⁾ revealed that just before swallowing, the 'Cingulate cortex' is associated with the activity of the 'Insula.' This may be interpreted as that, affection system may strongly interpose in the swallowing process to prevent health hazards; inversely, preferable food may generate pleasant emotion as a safe signal. Because taste provides essential information to evaluate safety and preference of food, we can easily understand how sweet and Umami tastes may initiate the swallowing process. Recently, our laboratory developed a method to elicit swallowing in humans using electrical stimulation of the pharyngeal wall. The method itself may provide a safe training program for patients with dysphasia. Application of glutamate to the pharynx as a chemical stimulant may increase effect of the electrical stimulation, as the pharyngeal wall is expected to have the necessary receptors.

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