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Review / Derleme

History of Oropharyngeal Organs and Swallowing

Orofaringiyal Organlar ve Yutmanın Tarihçesi

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Abstract

This review aims to present a brief historical perspective of the clinical development of swallowing since ancient times. It also highlights the discovery of the functional meaning of the oropharyngeal organs. These historical developments are enriched with some anecdotal details.

Keywords: Swallowing, oropharynx, larynx, historical review, dysphagia

Öz

Bu derlemede ilk çağlardan bu yana yutma ile ilgili kısa klinik gelişme incelenmiştir. Aynı zamanda orofaringiyal organların işlevsel anlamının keşfine de vurgu yapılmaya çalışılmıştır.

Anahtar Kelimeler: Yutma, orofarinks, larinks, tarihsel inceleme, disfaji

Introduction

In the historical record of early humans, the earliest remains of the Paleolithic age are associated with fishing and hunting. This means that the people of that period were not content with only plant-based foods-meat was also included in their diet. Eating plants and meat together increased the physical strength of these early humans, enabling them to tackle the natural world more effectively. Eating meat has been vital for the development of the brain, and it is worth emphasizing that the development of the nervous system associated with swallowing and the peripheral swallowing apparatus preceded the full development of the brain. With the discovery of fire, the eating of meats and other foods cooked over fire led to the more rapid development of the digestive system; moreover, the softening of food through cooking facilitated chewing and swallowing functions. With the domestication of sheep and cattle, the nutritional value of milk and dairy products was recognized (1). Swallowing is the first step in the act of feeding. For this vital function, cortical and subcortical structures, especially the bulbar swallowing center, work in coordination for both the protection of the respiratory tract and correct delivery from biting to the stomach. The fact that the larynx and respiratory tract in humans are adjacent to the oral-pharyngeal swallowing system and are in close proximity to each other is an evolutionary disadvantage in terms of swallowing (1). During swallowing, the airway must be closed to prevent swallowed material from entering the airway. Impairments to this coordination caused by dysphagia result in aspiration of the swallowed material.

In the fetal period, swallowing is one of the first motor responses of the pharynx, with pharyngeal swallowing occurring from the 12th week. Although the organs related to swallowing start to function in the intrauterine period, the respiratory apparatus only starts to function immediately after birth, with the newborn's first cry. In the infantile period, the larynx is located in the upper position, close to the floor of the mouth and nasopharynx. The most critical functional change in the postnatal period is the downward displacement of the larynx from the floor of the mouth. At about 18 months, it descends to its final position, and with

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it, the infant begins to speak; during this process, swallowing is further developed. Studies have demonstrated that in cases of anencephaly, swallowing can be performed and stimulated even after the cortical and subcortical areas are removed (2,3,4). This indicates that the oropharyngeal swallowing event, at least in the early stages, is not related to the cerebral cortex. In addition to the morphological adaptation of the pharyngeal and laryngeal regions during normal postnatal development, the descending neural control of the cerebral cortex over body movements begins (2). The chewing process reaches the adult level when the baby teeth fall out in childhood and are replaced by the permanent dental system. However, this may have caused chewing defects to precede dysphagia in early humans because pain, especially toothache, is a condition that was noted by people much earlier. In fact, in historical records, we see evidence of decayed teeth and the presence of the first physicians who tried to treat them. In Mesopotamian civilization, as recorded in the clay tablet writings of the Sumerians, considerable knowledge and experience was gained in dentistry, especially in dental caries. We can speculate that in ancient Egypt, dentistry might have been much more advanced; for example; as recorded in the papyrus, the first physician known by name was Hesy-Ra, known as "Chief of Physicians and Dentists" during his lifetime. Since 3000 BC, dentistry has been an important field and considered a separate profession. Archaeologists have detected both dental caries and attempts to treat teeth (1). In one mummy, extensive dental disease and a large, infected cyst were detected. The rarity of dental caries is probably due to the scarcity of sweet foods in Egypt. Opium was used for extreme toothache, and Egyptians believed that decayed teeth should not be left in place (1).

In ancient Greece, Alcmaeon of Croton, a pioneering thinker and physician, emphasized the importance of the brain. Although little is known about his life, he proposed that passageways, which he called poroi (or porous tubes), connected the tongue, ear, and nose to the brain, and he suggested that all sensations were connected with the brain (3), with the sense of taste perceived by the tongue and sense of smell by the brain (5). In fact, ancient Greek medicine was first recorded in Homer's Iliad. This book contains the first details on the bronchi, lungs, and diaphragm. Homer was born in Izmir in the 9th or 10th centuries BC and lived there for a long time. His real name was Melesiten, which he was given because he was born in a house on the banks of the old Meles Stream in Izmir (1). Although the vagus nerve was defined in the Hippocratic school, it was not given a name. However, Hippocrates reported that those who had head trauma also had swallowing disorders, along with other findings. Presumably, there were those who detected swallowing disorders before and after Hippocrates, but attention was often distracted from the symptoms of swallowing disorders that could not be identified through inspection and palpation because issues such as impaired consciousness and lung infection were prominent in these patients. However, we can make some interesting observations about the famous Pergamon Physician Galen, who influenced the middle ages. While making anatomical observations on a pig, he cut a branch of the vagus nerve. His purpose was to understand whether this nerve branch would affect the lungs. After cutting the nerve, the pig became silent, although it was apparently still enduring pain; thus, it lost its voice. Galen realized that he had cut the wrong nerve and decided that he had cut the laryngeal nerve innervating the vocal cords of the larynx. Thus, he discovered the nerves that made sound. He encountered a similar situation in two patients. He observed that they had lost their voices after undergoing surgery on their necks (these patients may have been gladiators because he treated gladiators for a long time) (1,3). During his research on animals, Galen observed the anatomical structure of the larynx and its nerves. These are the recurrent laryngeal nerves and were named in later centuries.

The last period of ancient Greek civilization was concentrated in Egypt, especially in Alexandria. Here, we encounter two important medical scholars, Herophilus and Erasistratus. This was the first time that human anatomy was systematically studied. They were given serious criminals and death row convicts and performed "vivisection" on them without anesthesia. For this reason, they were later referred to as butchers. Herophilus was interested in the digestive system, examining and describing the salivary glands, liver, and pancreas (1,3).

In the early periods of Islamic history, a physician named Ali bin Musa al-Rıza (766–818 AD) notably studied the subject of nutrition. He wrote a book called *Risale-i Zehebiye*, in which he recorded all the information of his age, as well as the following suggestions: *"Eat cold in summer, eat warm in winter, and eat at moderate temperatures in the other two seasons… Of course, do this according to your own strength and appetite; start with light foods first… Make them according to what you have and your capacity. You should have food every 8 hours, or you should have 3 meals every two days"* (6).

In the 10th to 13th centuries, key physicians were trained in the Andalusian Islamic civilization in Spain. In 1100 AD, Ibn Zuhr reported on swallowing, among other things. His full name was Ebu Mervan Abdulmalik bin Ebu'l Ala bin Zuhr, but in medieval Europe, he was known as Avanzoar or Abhomeron. He gave importance to clinical trials and wrote eight medical works, the most well-known and influential of which is *Teysir (Kitâbü't-Teysîr')*. Ebu Mervan conducted medical experiments on animals, suggesting tracheostomy after experiments on goats. He explained his own experiments and observations in detail in his works, including a description of a tumor occurring in the outer membrane of the heart, and the information he provided on pharyngeal paralysis and otitis media was original. As understood from his writings, Ebu Mervan was also the first physician to recommend trachea surgery and artificial feeding through the esophagus. In his book *Kitab-al Aghdhiya*, he made recommendations on nutrition and diet for a healthy life, suggesting the eating of special foods for every season of the year. Doctoral theses have been written on him and his works (7,8).

In the middle ages, barber physicians emerged, intervening in oral and facial diseases as well as performing tooth extraction. This is why they were referred to as barber physicians or barber surgeons.

As far as we know, records on ingestion date back to the 16th century. Known as one of the great physicians of the 16th century, Jean François Fernel (1497–1558), also an astronomer and mathematician, lived in Paris. He reported his clinical observations and thoughts and provided information on anatomy in his work *Universa Medicina*. He also used the terms "physiology" and "pathology" for the first time. He noted, "It is the muscles of the larynx that help in swallowing food" and determined the functions of these muscles. In addition, he was the first physician to record

that taste buds in the tongue were sensitive to oils. In this respect, he can be considered the pioneer of swallowing physiology (1,9,10).

Girolamo Fabrizio (1537–1619), also known as Hieronymus Fabricius, made key contributions to anatomy and medicine while he was Professor of Surgery and Medicine at the University of Padua, Italy. The most important among these was the definition of tracheostomy. He suggested passing a tube into the trachea, insisting that this would be very useful in cases of foreign bodies lodged in the trachea and of excessive edema. Indeed, his students used a curved silver tube and used tracheostomy during the diphtheria epidemic that occurred in Naples at that time. Fabrizio also made key contributions to the anatomy of the larynx and esophagus (1).

In the 17th century, the medieval scholastic attitude was discarded, and academics began to observe the world with a more realistic eye. Science and technology became more advanced, and scholars became aware of each other through books, thanks to the printing press. This was the period of the Enlightenment in Europe (1).

Antonio Maria Valsalva (1666–1723) was an Italian anatomist and clinician who was also interested in surgery. He was a student of Marcello Malpighi and studied the pharyngeal muscles, describing the cricopharyngeal sphincter (a letter C-shaped muscle located between the pharynx and esophagus). He worked on the function of the tube (eustachian tube) connecting the middle ear and pharynx and introduced the Valsalva maneuver and its effects, named after him, to medicine, writing about it in his book *De Aure Humana Tractatus* for the first time. Giovanni Battista Morgagni, a student of Valsalva, collected all of Valsalva's writings and published a biography of him (11,12,13).

Thomas Willis (1621–1675) was a famous English physician. He observed and wrote about dysphagia. He ruled that a woman, who made a strange noise after drinking coffee, was coughing because her throat was being tickled. This might have been an occurrence of laryngeal aspiration, although he did not spend much time dwelling on it. His anatomical and clinical knowledge was useful to medicine, especially the Willis polygon, which was named after him. He used the term "neurology" for the first time and contributed greatly to the identification of cranial nerves, giving the vagus nerve its current name (1,3,4,14,15). The list of seven pairs of cranial nerves that Galen identified was accepted until Willis described the nine pairs of cranial nerves in the late 16th century. From the time of Galen to the 16th century, these nerves were called "brain nerves", but Willis placed the origin of the nerves inside the skull. In Willis's *Cerebri Anatome* (1664), the cranial nerve classification consisted of nine cranial nerves. For example; nerve VII included both the facial and vestibulocochlear nerves, nerve VIII (vagi/traveler couple) contained the cranial root of the accessory nerve as well as the glossopharyngeal and vagus nerves, and nerve IX consisted of the hypoglossal nerve and spinal cord root of the accessory nerve. This definition remained valid for 114 years until the modern classification of 12 pairs of cranial nerves by Samuel Thomas Soemmerring (1755–1830) was accepted (14,15).

Joseph François Magendie (1753–1855) was one of the leading neurophysiologists of his age. He was a pioneer of experimental physiology. In 1825, Magendie stated that swallowing was divided into three phases: the first is the oral phase, the second the pharyngeal phase, and the third the esophageal phase (16).

Although Magendie's approach represents the most rational approach in this century, it is useful to note a few other scientists who lived in the 19th century. Marie–Jean Pierre Flourens (1794–1867) was a French researcher who often studied pigeon brains and used ablation techniques. He stated that the medulla oblongata was responsible for respiration, locating the center that controls cardiac rhythm there. He wrote that the medulla oblongata fulfilled an integrative function related to the survival of the organism as a whole, referring to it as the "vital node" (3).

Marshall Hall (1797–1857), an English scientist, studied reflexes in the brain and spinal cord. As a result of his experiments, he accepted that breathing was controlled reflexively, and sneezing, coughing, vomiting, and swallowing were reflexes. Consequently, he suggested the artificial respiration method (3). Marshall Hall probably agreed that the medulla oblongata controlled respiration and swallowing, and he examined the swallowing reflex in various diseases. However, by a twist of fate, he died from dysphagia, probably caused by cancer in the esophagus (5). British surgeon David Bayford (1739–1790) defined this condition, which he thought originated from an aberrant right subclavian artery, as "dysphagia lusoria" in the autopsy of a 62-year-old woman who developed severe malnutrition due to the inability to swallow, reporting her case in 1787 (17). Austrian neurologist Ludwig Türck (1810–1868) was the first physician to use the laryngoscope (13).

Sir Charles Bell (1774–1882) focused on laryngeal disorders and swallowing, also making many contributions to neurology, facial nerve anatomy, and neurophysiology. He was the first to describe the pharyngo-esophageal diverticulum, which would be named after the pathologist Zenker in later years, with its anatomical features. One of his patients, who had had dysphagia for a long time and was relieved by bougie dilation, requested that his body be used for dissection after his death. Bell observed the following at autopsy: "I found a bag protruding from the lower and posterior part of the pharynx and pushed into the space between the esophagus and the spine. The bag can be described as a hernia or protrusion of the inner layer of the pharynx between the pharyngeal muscle fibers". Bell thought that his patient had "spasmodic swallowing difficulties" and that such a herniation might be caused not only by a defect in musculature but also hypertrophy of the upper esophageal muscle. In addition to this case, Bell described cases of dysphagia that might be caused by esophageal foreign bodies, structural strictures, cancer, or tuberculosis. He believed that "spasmodic dysphagia" caused by muscle spasm was also responsible for dysphagia (18).

With the routine use of X-rays in hospitals in the 20th century, the ability to examine the esophageal passage with barium in humans has contributed significantly to the understanding of swallowing physiology and pathologies. Cannon and Moser (1898) were the first to examine swallowing using the X-ray technique, reporting that the epiglottis moves to close the larynx opening during swallowing (19). Mosher revealed the esophageal web for the first time radiologically in 1927 and reported that the epiglottis closes the laryngeal inlet during swallowing (19). However, these early methods did not display details of the oropharyngeal region; thus, modified barium swallowing techniques were developed by different scientists over time. Chief among these are researchers from the USA such as Dodds, Donners, Doty, and Logemann. Logemann wrote many articles and books on swallowing and

dysphagia, contributing significantly to the training of the speech and swallowing specialists who have routinely worked with patients in recent years. In addition, thanks to otolaryngologists and gastroenterologists, manometry technology, which measures pressure in the pharynx and esophagus during swallowing, has been developed, with endoscopic methods also added. Turning to another research area of historical importance, Doty and Bosma (20) performed electromyography (EMG) in the upper esophageal sphincter and other muscles involved in swallowing in animals, and their study was published in 1956. Later, EMG was used on other nonhuman species, and these EMG studies were used to understand swallowing mechanisms (20).

Systematic and widespread studies on swallowing physiology and disorders using EMG methods were conducted between 1992 and the 2020s (2,12,21,22,23,24,25). These authors focused their studies on neurogenic dysphagia, using different physiological techniques.

In recent years, swallowing research has gained momentum with the use of brain imaging techniques, including functional magnetic resonance imaging and positron emission tomography. These studies have especially tried to clarify the cortical and subcortical swallowing mechanisms (26,27,28).

Before we finish this history of swallowing research, we should pay tribute to the scientists who conducted basic and experimental research. Thanks to their scientific efforts, human swallowing studies have been able to gain momentum. We can name many, but among them we pay particular respect to Arthur J. Miller (USA), Barry J. Sessle (Canada), and Andre Jean (France).

Ethics

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Authorship Contributions

Concept: C.E., İ.A., Design: C.E., İ.A., Data Collection or Processing: C.E., İ.A., Analysis or Interpretation: C.E., İ.A., Literature Search: C.E., İ.A., Writing: C.E., İ.A.

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