

A Review Of Galen's Contribution To Anatomy With Special Reference To The Digestive System

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Abstract:

Digestive system is crucial for our survival and plays a significant role in the normal functioning of other body systems. It breaks nutrients of food into absorbable form which is used by our body cells and eliminates the waste. It includes the gastrointestinal tract and accessory digestive glands. Numerous scholars have made significant contributions to the anatomy of the digestive system. However, the major breakthrough in this field was made by Galen, a great Roman physician and anatomist. He was the first physician who reported the sensitivity of teeth and their ability to differentiate between hot and cold. He also explained the anatomy of all muscles of the tongue and of those that moves the lower jaw. Galen believed, the food is concocted in stomach by digestive juices and stomach movements, and conveyed to the intestine, where the intestinal wall facilitates absorption of mixture by veins. The mixture is then transported to liver by veins, converted into nutritious new blood by mixing with natural spirit and distributed all over the body. He considered the liver as the centre of venous blood system and blood formation. Although Galen had a remarkable impact on various areas of medicine, his greatest accomplishment was his contribution to the knowledge of anatomy.

Key Word: Anatomy(Tashreeh-ul-Badan), Digestive System(Nizam-e-Hazm), Galen(Jalinus), Intestine, Liver, Stomach, Teeth.

Date of Submission: 25-03-2024

Date of Acceptance: 05-04-2024

I. Introduction

Tashreeh-ul-Badan(Anatomy) is the basic and fundamental branch of *Tib-e-Unani* which deals with the structural organization of the human body, as it forms the basis for every field of medical science [1]. The term **anatomy** was derived from the Greek word '*temnein*', which means "to cut" which reflects the practice of dissection that is a fundamental aspect of the study of anatomy [2]. The essential knowledge of human anatomy has been a fundamental principle of medicine and surgery for centuries [1].

The great anatomist of antiquity **Claudius Galen (Jalinus)**[129-200 AD] of Pergamon was also considered to be the most proficient physician, surgeon and philosopher of the Roman Period [3]. By his extensive anatomical studies and dissections on various animals, Galen was empowered to describe the anatomical variations between species therefore became the pioneer in comparative anatomy and also pioneered experimental physiology. Despite being one of the most influential authors of history by writing more than five hundred dissertations of his discoveries and observations on medicine, physiology, anatomy, philosophy and medical ethics, he also invented many medical tools for surgery and dissection [4]. Galen considered the human body as one united unit that cannot be divided and his thought was based upon the four elements and doctrine of the *pneuma*. He was excellent in the study of bones, muscles, nerves, digestive and respiratory systems [5].

The mechanical and chemical process by which the food we eat is broken down into smaller molecules that can be absorbed and utilized by our body cells for growth, cell repair and energy is called digestion [2]. The **Digestive System(Nizam-e-Hazm)** collectively consist of the gastrointestinal(GI) tract also known as the digestive tract which is a long, hollow, twisting tube extending from the mouth to the anus and accessory digestive glands. The series of hollow organs that contrived GI tract are the mouth or oral cavity, oesophagus, stomach, small intestine and large intestine which includes the rectum and the anus. The accessory digestive glands comprise the liver, gall bladder and pancreas which significantly contribute in the process of digestion along with the enzymes secreted from the gut.

Galen's scientific work contributed greatly to the study of the digestive system. Besides describing the anatomy of stomach with its layers he also endeavoured to its function and importance in digestion [4]. He also

systematically described numerous muscles of human body, including all four muscles that move the lower jaw and all muscles of the tongue [5,6]. Galen was the first physician to report the sensitivity of teeth [3].

II. Galen's Contribution In Anatomy

The renowned Roman anatomist gained his extensive anatomical knowledge through external observation of humans and dissections and experiments on lower animals such as Barbary apes (or African monkeys), pigs, sheep, and goats. He even considered the internal organs of humans to be not very different from those of pigs [6]. While there was a lot of debate about whether Galen dissected humans or not, most scholars believed that he only did dissections on animals and correlated his knowledge to the external observation of humans to describe human anatomy. Galen set a milestone with his remarkable literature, writing 15 books on anatomy (six of which were preserved in Arabic), his astounding work seventeen-volume, "*On the Usefulness of the Parts of the Human Body*" and "*On Anatomical Procedure*" which detailed all the anatomical findings obtained after dissections and observations. That's why he was named the **Master of anatomy** [3,5]. He urged physicians to study the anatomy of the human body and proclaimed that, "*diseases were manifestations of impaired anatomical functioning, so a fundamental understanding of the human structure was necessary to diagnose and treat diseases*". He affirmed that the working body is not understandable without knowledge of its structure. According to Galen, "*We will gain knowledge about the seat, the number, the peculiar matter, the size, the shape, and the composition of every part of the body by dissecting lower animals*" [7].

Regarding choosing the correct animal for dissection, he stated that the most suitable animals for dissection were those 'who have a round face' and believed that the dissecting animal must have a close similarity of their nervous system to that of humans [7]. Galen proposed successful new treatments for injured tendons and nerves and recognized that tendons are 'surrounded by sheaths that protect them from injury and from attrition by the bones' [8]. Galen was the first physician who ensured that arteries carry blood, not air, as the majority of physicians had previously believed and also was the first to recognize that there are distinct differences between venous (dark) and arterial (bright) blood [9]. He divided the soul (pneuma) into three parts, each allocated to different parts of the body. The rational faculty of the soul is located in the brain, the spiritual one in heart and the desiderative part in the liver [4]. He thought that 'the liver was the centre of the venous blood system and the new blood formation' [10]. Galen noted the importance of the spinal cord, motor and sensory loss following the ligation of a peripheral nerve in its distributional area, and experimentally demonstrated the function of the recurrent laryngeal nerve, characterizing it as the vocal nerve or nerve of the speech and responsible for voice production[11].

III. Galen's Concept Of The Gastrointestinal Tract

The previous knowledge of anatomy was believed to be laid by Hippocrates. Galen strictly followed the theories of Hippocrates and Aristotle and also tried to combine their writing. He quoted from their beneficial opinions, concerning the power of life, nutrition and the continual efforts on the vital unity of humans to regain normal health of the body in case of sickness or wounds [5].

The first digestion of food started in **Mouth or oral cavity(Fam)** with the help of salivary enzymes, teeth and tongue. Galen was the first physician who gave a systemic description of some muscles and nerves of the oral cavity. Along with describing the all muscles of tongue, he did some experiments on animals which involved the nerves that control the movement of the tongue and production of speech. He correctly reported that muscles which moves the lower jaw, are four pairs in number, the temporalis, masseter, digastric, and lateral pterygoid muscles. He also mentioned the four muscles of the lip [6]. Galen believed that teeth are solid and only bone has sensitivity and the power that comes from the brain to distinguish between hot and cold [3,12]. Galen testified its power of sensation with length and admitted that, he suffered from toothache, and at that time carefully investigated whether the teeth themselves felt pain, he also mentioned that nerve (nervus trigeminus) which is responsible for this. Galen wrote in his book, "*De compositione medicamentorum secundum locos*" that, "*the tooth not only hurt but also throbbed like inflamed flesh*" [12].

Galen considered the **oesophagus(Mari)** as part of the body responsible for only transporting food from the mouth to the stomach, so food did not underwent any changes in the oesophagus[13]. He described the layers of the oesophagus along with its structure and function, which helps in swallowing food. Galen dissected and did experiments on lower animals to see the complete process of swallowing and digestion and commented, "*Prior to dissecting an animal, all of its outer and inner layers must be separated in such a manner that no vein, artery, or nerve should be cut. After feeding the animal and making a longitudinal cut that went from the jawbone to the chest to remove the outer layer of the oesophagus (the one with transverse fibers), you can observe that the animal is still swallowing food despite the termination of its peristaltic movement. This experiment has now been repeated on a different animal, but this time with numerous transverse cuts made on both oesophageal layers. You will now discover that although the animal can still swallow, the inner layer is no longer functional. This indicates that the animal can swallow from each and every layer, though not as easily, as from both*

layers". This process of dissection will also provide information regarding that, while swallowing, some air is also passed through the pharynx which is swallowed along with the food. Also, when the outer layer is contracting, the air along with the food easily enters into the stomach but when only the inner layer is working, then this air expands the inner layer and slows down its working and becomes a barrier to the entry of food [14]. Galen noted that oesophagus has a relatively lesser amount of blood vessels as compared to the stomach [13].

Galen was always curious about why any organ has its particular structure. The great roman physician considered **stomach(Meda)** as the true organ for digestion. He described the structure and anatomy of the stomach according to its functional purpose. Galen stated that the stomach has three coats of which two coats are muscular-an inner and an outer coat and the outer coat is more fleshy in the gullet [13]. According to modern knowledge, we know that the stomach is actually made up of three muscular layers with longitudinal, circular and oblique fibers, but Galen considered the oblique fibers as a part of the inner layer so he commented that the fibers of the inner layer are longitudinal in nature, and the outer layer is circular and another type of fibers are also present in the stomach which are oblique in nature but this is part of the inner layer and present along with longitudinal fibers [14]. He stated that food undergoes both mechanical and qualitative changes in stomach and suggested the functional purpose of the inner coat is traction due to having straight fibers and the outer coat is peristalsis because its fibers are transverse [13]. Galen enlightened that all three layers have separate powers which act on food, the elongated fibers have power of absorption, transverse fibers have the power of excretion and oblique fibers have retention power [14]. He then mentioned the three functions of stomach, the first one is 'to receive food from oesophagus', the second one is, 'digest the food', and last one is, 'deliver it to the small intestine' [13]. Galen found the work of stomach not just as the physical digestion of food, but also as a filter by sorting the components of food into useful ones and the useless foreign elements which separated from useful substances. He tried to differentiate between blood spitting and blood vomiting by enlightening the origin and passage of blood during spitting and vomiting [3].

Galen conducted studies on digestion by feeding pigs with different diets and observing the movement of food down by opening their stomach. He found that the best time to dissect the stomach was after three or four hours of feeding, when food was still present in the stomach [15,14]. Galen noted that the stomach's movement during digestion was more complex than the movement of the intestine. The peristaltic movement in the stomach began only when the mouth of the stomach opened. Galen observed that the inner layer of the stomach was similar to the intestine, while the outer layer became more muscular in structure [14].

Galen considered the **intestine(Am'a')** as a major organ for the absorption of food. He described the 'pylorus' as the part of the small intestine that emerged directly from the stomach. He mentioned its anatomical features distinguished from other parts of the small intestine as it did not form a coil and ran along the spine as a continuation of the stomach [13]. Galen clarified that those organs that have only one layer in their wall also have both transverse and longitudinal fibers. He described the intestine as the only organ having two coats and both are made up of transverse fibers. Galen wrote about peristaltic movement of the intestine, "*I have opened the peritonium of live animals several times and observed that all of the intestines are constantly in a contracted position with peristaltic movement upon its contents*" [14]. According to Galen, the small intestine's functional purpose is that nutriment is still undergoing concoction while passing through it [13]. He discussed the importance of the duodenum as the bile duct leads into it. Galen conducted experiments on the spinal cord and observed the paralysis of the intestine due to injury in the lower spine[5]. He also differentiated between colic from intestine and colic from kidney stones [3]. He distinguished catarrh, colic, dysentery, cholera, intestinal parasites, dropsy, ascites, stomach hemorrhage, diabetes, gastric disturbance, vertigo, apoplexy, paralysis, epilepsy, and other diseases [5].

IV. Galen's Opinion On Accessory Digestive Organs

Galen considered **liver(Kabid)** a most crucial organ as it is responsible for new blood formation and origin center of natural spirit [15]. He demonstrated that blood which present in left ventricle was actually originated in the liver from 'chyle' which was derived from stomach and intestinal tract by the food, chyle transported into the liver by the portal vein where it endowed with "natural spirit" and ultimately form the new blood, the natural spirit in the liver was thought to responsible for functions of nutrition, growth and reproduction [16]. The blood then goes towards lungs, and then travels into the whole body by the veins and responsible for nutrition, formation of flesh and other substances [3]. In Galen's view, veins are originated in the liver and it is the center of venous blood system [12]. Galen also established connections between the liver and certain appetitive sentiments like hunger or thirst [5].

Galen's central concept is the tripartite division of the soul. He concluded that the '**Pneuma'(Rooh)**, which is the carrier of life or its causative or the vital force that energizes the body to perform its functions perfectly, enters into the body through respiration and gets divided into natural spirit(physical pneuma), animal spirit(psychic pneuma) and vital spirit(life pneuma) which are located in the liver, brain and heart respectively [4,17]. Natural spirit goes deep into the veins and manufactures the blood, responsible for growth and

reproduction of the human body. Vital spirit controls the viability and the temperature of the human body and the psychic spirit is responsible for the function of the brain and nerves [15].

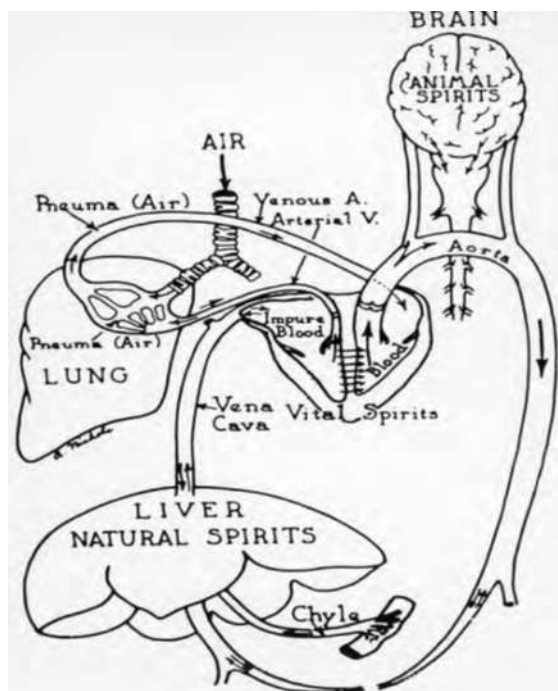


Fig.1. Galen's Conception Of The Flow Of Pneuma(From A History Of Human Anatomy By TVN Persaud)

V. Discussion And Conclusion

Majority of the Galen's anatomical knowledge came from animal vivisection, attending the wounds sustained by the gladiators and less from autopsy studies. Galen studied bones from tombs that were destroyed [6].

Galen found that muscles of walls of oesophagus and the cardiac portion of stomach has similar structure. Galen considered stomach as true digestive organ, as he studied its anatomy and process of digestion by dissect an animal after feeding. Through his valuable experiments, he described the three coats of stomach on its functional purpose [13]. Liver, the crucial vital organ is source of new blood formation by Galenic view. His work on the muscles and nerves provides the reader with numerous observations that are still of value today, he gave the anatomy of about 500 muscles and named the glossopharyngeal, vagus and spinal accessory nerves as the sixth pair of nerves, hypoglossal was considered to be the seventh [18]. He did experiments involving the nerves that control movement of the tongue and production of speech and reported the sensitivity of teeth and power of differentiation between hot and cold.

The legendary anatomist had left a valuable heritage of knowledge and methodology through his dissections and developed the idea that every organ in the human body was created by God in the best possible form and for its perfect use [19]. This compiled knowledge of anatomy developed the basis for every medical study done on digestive system.

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