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Review Article

Galen's (Jalinūs) Contributions to the Advancement of Knowledge in the Anatomy of the Nervous System: A Historical Analysis

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Abstract

Jalinūs (Galen), a Greek physician, writer, and philosopher, made significant contributions to the advancement of medical knowledge and conducted numerous dissections and observations of the brain and nerves, providing detailed descriptions of their structures and functions. His contributions to the nervous system anatomy and disease theory were significant, and he was the first to identify the brain as the site of termination for all five senses, which laid the foundation for further research into the functions of the nervous system. His theories on the nervous system were revolutionary, challenging prevailing beliefs and paving the way for further research, and his anatomical drawings and descriptions helped uncover the neuromuscular system under the control of the brain, as well as the structure and function of the respiratory and speech systems. Additionally, his studies on respiration and the recurrent laryngeal nerve solidified the idea that the brain is the site of rational power guiding human behavior. Furthermore, he differentiated sensory from motor nerves by palpation and believed the brain and nerves were responsible for sensation and thought. *Jalinūs*' work on the nervous system, which included the vivisection of animals, laid the groundwork for future discoveries and advancements in the field. Despite these controversies, *Jalinūs* (Galen) remains significant and continues to influence modern medical practice. In this paper, we have reviewed the contributions of *Jalinūs* (Galen) to the advancement of knowledge in the anatomy of the nervous system.

Keywords: *Jalinūs*, Brain, Ventricles, Spinal cord, Neuroanatomy, Recurrent laryngeal nerve.

INTRODUCTION

Jalinūs (Galen) made significant contributions to the advancement of knowledge in the anatomy of the nervous system. One of his greatest achievements was providing a natural theory of disease, which provided a different perspective on the cause and cure of illnesses as opposed to supernatural ideas [1]. *Jalinūs* (Galen) understanding of medicine led to the adaption of the theory of four humours and created the theory of opposites, which challenged old ideas and encouraged people to look for different solutions within the medical world [1]. In terms of the nervous system, *Jalinūs* (Galen) recognized the importance of the brain as a supercomputer for the human body system, with the brain controlling cognition and willed action [1,2]. Galen's perspective on the brain's role in cognition emphasized the importance of sensory information processing in the sensus communis [2]. While he acknowledged the brain as the central hub for sensory data interpretation, he diverged from *Erasistratus*'s hypothesis regarding the relationship between brain convolutions and intelligence [3,4]. Galen's views on the brain's functions in cognition contributed to the understanding of the brain's complex role in processing sensory information and shaping human perception. Galen's (*Jalinūs*) studies of respiration and of the recurrent laryngeal nerve helped solidify the knowledge that the brain, not the chest, was the site of rational power that guides human behaviour [2]. Galen's experiments demonstrated a clear correlation between the intersection of the recurrent laryngeal nerve and the loss of vocalization produced by the larynx [5]. Further, *Jalinūs* (Galen) differentiated sensory from motor nerves by palpation and believed that the brain and nerves were responsible for sensation and thought, with the brain being the site of termination of all five senses [2,6].

Galen's (*Jalinūs*) physiological theory was widely accepted and difficult to challenge in the succeeding centuries, with his theory of the body consisting of three connected systems: brain and nerves; heart and arteries; liver and veins [6]. Galen's (*Jalinūs*) anatomical drawings led to discoveries of the neuromuscular system under the control of the brain, including distinguishing seven pairs of cranial nerves and identifying the structure and function of the urinary apparatus [1][7]. Though his dissections of lower animals led to errors in his understanding of human anatomy, *Jalinūs* (Galen) was a pioneer in research about the human spine and was the first physician to study what happens when the spinal cord is transacted at multiple different levels [7,8]. Overall, *Jalinūs* (Galen) played a major role in the discoveries of the central nervous system through his dissections and vivisections of animals, which helped him accurately describe the human spine, spinal cord, and vertebral column [8].

OBJECTIVES

1. To examine Galen's primary anatomical theories related to the nervous system.
2. To trace the transmission of Galenic neuroanatomical knowledge through the Islamic Golden Age and into the European Renaissance.
3. To evaluate the accuracy and limitations of Galen's findings in light of modern anatomical science.

Overall, the objective of this research is to recognize Jalinūs as a significant contributor to the field of neuroanatomy, whose impact calls for a revival of scholarly interest.

MATERIALS AND METHODOLOGY

This study is a qualitative historical analysis focused on Galen's contributions to neuroanatomy. It uses primary texts written by Galen, such as his treatises on anatomy and along with translations by medieval Islamic scholars (e.g., *Ḥunayn Ibn Ishāq*, *Zakriyā Al-Rāzī*, *Ibn Sīnā*). Secondary sources include academic books and articles that discuss the history of medicine and Galen's influence in both Islamic and Western medical traditions. The study examines how Galen's ideas evolved over time and their relevance to modern neuroscience.

Galen's (*Jalinūs*) early life and education

Jalinūs (Galen), born in Pergamum, Asia Minor (now Turkey), in 129 AD, was a prominent physician and anatomist of the Roman Empire [9]. Galen's (*Jalinūs*) father was a wealthy architect who encouraged his son's education, and he received a comprehensive education in philosophy, mathematics, and logic during his childhood and early education [10]. At the age of 16, *Jalinūs* (Galen) began his medical training in Alexandria, Egypt, where he studied under some of the most renowned physicians of the time [11]. He learned about anatomy, physiology, and the use of medicinal plants, among other things, and developed a deep interest in the workings of the human body.

After completing his medical training in Alexandria, *Jalinūs* (Galen) embarked on a series of travels and medical practices [12]. He travelled extensively throughout Greece and Asia Minor, treating patients and conducting research. During this time, he continued to study anatomy and made significant contributions to the field. For example, he was the first to recognize that the circulatory system was composed of two separate circuits: one that carried blood from the heart to the lungs and another that carried blood from the heart to the rest of the body [10]. He also made important observations about the nervous system, including the fact that the brain was the site of termination of all five senses [12].

Throughout his life, *Jalinūs* (Galen) emphasized the importance of anatomy in medical practice [13]. He believed that knowledge of the body was essential for every medical practitioner and that anatomy was the foundation of all medicine. Galen's (*Jalinūs*) reliance on anatomy and experimentation demonstrated his belief in the value of observation in medicine [14]. He produced a completely systematized approach to anatomy and used anatomical knowledge as evidence of excellence in medical practice [9]. *Jalinūs* (Galen)'s work on anatomy, physiology, and medicine had a profound impact on the development of Western medical knowledge [9]. His teachings incorporated much of the ancient Greek traditions, and his contributions to the field of anatomy of the nervous system have stood the test of time [15].

Galen's (*Jalinūs*) contributions to the anatomy of the nervous system

Galen's (*Jalinūs*) contributions to the advancement of knowledge in the anatomy of the nervous system were significant and far-reaching [10]. He conducted numerous dissections and observations of the brain and nerves, providing detailed descriptions of their structures and functions [9]. Galen's (*Jalinūs*) work on the nervous system was ground-breaking, as he was the first to identify the brain as the site of termination for all five senses: touch, taste, smell, sight, and hearing [12]. This discovery laid the foundation for further research into the functions of the nervous system, and Galen's (Jalinūs) work on the anatomy of the nervous system remains influential to this day [13].

Jalinūs (Galen) provided a detailed description of the meninges, emphasizing their role in protecting the brain (*Dimagh*) with the dura mater (*Umm-i-Ghaliz*) as the fibrous outermost layer and the pia mater (*Umm-i-Raqiq*) as the inner delicate layer. During his dissection of the brain (*Dimagh*), *Jalinūs* (Galen) identified the corpus callosum as a significant internal structure responsible for connecting the two cerebral hemispheres.

Jalinūs (Galen) further explored the brain's ventricular system, highlighting the connection between the anterior ventricles, middle ventricle (*Batan*), and posterior ventricle leading to the spinal cord (*Nukha*). He also recognized the choroid plexus within the ventricles as a complex network of veins and arteries. Delving deeper into the brain (*Dimagh*), *Jalinūs* (Galen) discovered unique structures such as the pine-cone shaped conarium near the aqueduct, the white-colored fornix resembling a vaulted roof supporting the cerebral hemispheres, and the infundibulum connecting to the pituitary gland. *Jalinūs* (Galen) also identified rounded protrusions in the upper brainstem as the 'buttocks' and described the vermiform process as a narrow worm-like structure between the two halves of the cerebellum. The term "vermis" was later used by subsequent writers to refer to a channel that controlled the flow of pneuma into the fourth ventricle [14,15]. According to *Jalinūs* (Galen), the brain, or "*Dimagh*," is considered the hegemonikon because it is solely responsible for both sensation and voluntary movement [16-19]. *Jalinūs* (Galen) further asserts that the brain, the location of the hegemonikon, not only serves as the source of nerves but that the nerves are actually made of the same substance as the brain itself.

Jalinūs (Galen) also explains that a nerve or "tonos" originates from either the brain or the spinal cord, and a single organ is given a name that describes two actions - sagging and pulling tight. This description highlights the interconnectedness and functional relationship between the brain, nerves, and the body's ability to sense and move voluntarily [20, 21].

It is worth mentioning that *Jalinū*s (Galen) also recognized the fact that the spinal nerves do not provide innervations to all areas of the body. Specifically, he observed that the nerves responsible for controlling the face and head always originate from the brain, known as cranial nerves [22,23]. *Jalinūs* (Galen) made a significant contribution to the understanding of the nervous system by identifying seven pairs of cerebral nerves. These cranial nerves were believed to be nerves of sensation, as they originated from the brain. In contrast, *Jalinūs* (Galen) recognized the 30 pairs of spinal nerves as the nerves of motion. This distinction between the cranial and spinal nerves provided valuable insights into the different functions of these nerve pairs. In addition to his identification of the cranial nerves, *Jalinūs* (Galen) also had a comprehensive understanding of the cerebral ventricles, their communications, and the choroid plexus. His keen observations allowed him to describe the cerebral hemispheres, as well as the third and fourth ventricles. These detailed descriptions provided a deeper understanding of the structure and function of the brain, contributing to the overall knowledge of the nervous system.

Galen's (*Jalinūs*) understanding of this anatomical connection highlights the intricate relationship between the nervous system and the various parts of the body.

Furthermore, *Jalinūs* (Galen) emphasized that the muscles play a crucial role in moving specific organs. However, he noted that the muscles themselves rely on certain nerves originating from the brain in order to be activated. *Jalinūs* (Galen) conducted experiments where he obstructed one of these nerves with a ligature, resulting in immediate paralysis of both the muscle connected to the nerve and the corresponding organ it controls [15]. This observation further supports Galen's (*Jalinūs*) comprehensive understanding of the intricate interplay between nerves, muscles, and bodily functions.

Galen specifically focused on the "brain nerves" and meticulously counted seven pairs of them and possessed knowledge about the trajectory of spinal nerves [24]. In his remarkable studies, Galen provided a detailed account of the vagus nerve by dissecting adult beef, pig, and macaque specimens. However, it is worth noting that he did not document his findings on the vagus nerve in humans. Galen provided detailed descriptions of the vagus nerve, referring to it as the "sixth pair of nerves from the brain," the "great nerve," and the "nervus tornabilis" [25]. Additionally, he identified the recurrent laryngeal nerve as an "upward recurrent nerve" [25]. These terms used by Galen demonstrate his understanding of the anatomical structures and their functions within the human body. Through his observations and descriptions, Galen contributed significantly to the field of anatomy by accurately identifying and naming important nerves such as the vagus nerve and the recurrent laryngeal nerve. His terminology and classifications have stood the test of time, providing a foundation for further research and understanding of the nervous system. Galen's work continues to be studied and referenced in modern anatomical studies, highlighting the lasting impact of his contributions to the field. His meticulous observations and descriptions of these nerves contributed significantly to our understanding of the human nervous system.

Jalinūs (Galen) specifically named the glossopharyngeal, vagus, and spinal accessory nerves as the sixth pair of nerves, while considering the hypoglossal nerve as the seventh pair. This classification further expanded the knowledge of the nervous system and helped in distinguishing between different nerve pairs based on their specific functions.

In addition to his anatomical observations, *Jalinūs* (Galen) also identified the functions of the nervous system [26]. He believed that the brain and nerves were responsible for sensation and thought, while the heart and blood vessels were responsible for circulation [26]. Galen's (*Jalinūs*) theories on the nervous system were revolutionary, as they challenged the prevailing beliefs of his time and paved the way for further research into the functions of the nervous system. His reliance on

anatomy and experiment demonstrated his belief in the value of observation in medicine and helped to establish the importance of anatomical knowledge in the field of medicine [7].

Galen's (*Jalinūs*) contributions to the anatomy of the nervous system were significant and multifaceted [27]. His anatomical drawings and descriptions helped to uncover the neuromuscular system under the control of the brain, as well as the structure and function of the respiratory and speech systems [11]. Galen's (*Jalinūs*) work on the nervous system was also heavily influenced by the natural philosophy of Plato and Aristotle, which he frequently integrated into his observational practice [28]. Overall, Galen's (*Jalinūs*) contributions to the anatomy of the nervous system represent a crucial milestone in the history of medicine, laying the groundwork for future discoveries and advancements in the field [15].

DISCUSSION

Galen's contributions to neuroanatomy are pivotal in medical history, particularly his encephalocentric view that identified the brain as the primary organ for sensation and movement, contrastively challenging earlier heart-centered beliefs. Through vivisection of animals, he mapped cranial nerves and the spinal cord, establishing early principles of neural function localization. His pneuma theory suggested that vital spirits are processed in the brain's ventricles and distributed via "hollow" nerves, proposing specialized cognitive functions for different ventricular compartments, which foreshadowed later concepts of brain modularity.

Galen's works, preserved and translated in the Islamic Golden Age, influenced scholars like Avicenna and were later re-evaluated during the Renaissance, leading to critical insights despite some inaccuracies. Comparatively assessing his findings with modern neuroscience highlights both prescient accuracy such as spinal cord injury predictions and significant limitations, including misunderstandings of cortical functions and nerve structures. This comprehensive evaluation emphasizes Galen's foundational role, encouraging renewed exploration of his legacy in the context of contemporary neuroscience and ethical experimentation.

CONCLUSION

Galen's theories significantly contributed to the field, but faced criticism, particularly for his doctrine of ventricular localization of mental functions, which attributed perception, imagination, and memory to the brain's ventricles. This theory has been debunked but greatly influenced nervous system studies for centuries. Additionally, his comparisons between animal and human anatomy often led to inaccurate conclusions about human anatomy. Despite these controversies, Galen's contributions to nervous system anatomy remain influential in modern medical practice.

Galen's contributions to understanding the anatomy of the nervous system were profound and influential. His education in Alexandria and subsequent medical practices provided a foundation for his groundbreaking work, including dissections and observations of the brain and nerves, leading to theories that shaped medical knowledge for centuries. Despite controversies, Galen's legacy continues to impact future medical practitioners significantly.

Conflict of Interest: The authors declare no conflicts of interest.

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Ethical Considerations

Since this study is based on historical literature, it did not involve any human or animal subjects, and therefore, ethical clearance was not necessary. Nonetheless, academic integrity was upheld through appropriate citation and referencing methods.

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