Richard Lower (1631–1691): acknowledging his notable contributions to the exploration of the nervous system

Historical vignette

Richard Lower (1631–1691), an anatomist and physician, was born in St. Tudy, Cornwall, England, and became an avid follower of William Harvey and a pupil to Sir Thomas Willis. Unfortunately, little is written of his contributions to the study of the nervous system despite his successful medical career and his regard as one of the most significant English physiologists of the 17th century. Lower was best known for his remarkable studies within the cardiovascular and respiratory disciplines. However, although not as well documented and thus often overlooked, Lower produced noteworthy advancements within the field of neuroscience such as studying the hindbrain innervation of the heart, CSF formation and circulation, cranial nerve function, and the structural sources of seizures. Some have even attributed the results of Willis’ anatomical and physiological studies to Lower rather than to Willis himself. Lower has not received the recognition he is owed as a highly skilled and trained anatomist and physician. In this paper, the neurological contributions, with a brief mention of challenges, delivered during the 17th century by this influential historical physician will be highlighted with an emphasis on the impact each contribution made.

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But for the more accurate performing this work, as I had not leisure, and perhaps not wit enough of my self, I was not ashamed to require the help of others. And here I made use of the Labours of the most Learned Physician and highly skilful Anatomist, Doctor Richard Lower, for my help and Companion; the edge of whose Knife and Wit I willingly acknowledge to have been an help to me for the better searching out both the frame and offices of before hidden Bodies. Wherefore having got this help and Companion, no day almost past over without some Anatomical administration; so that in a short space there was nothing of the Brain, and its Appendix within the Skull, that seemed not plainly detected, and intimately beheld by us. After this, when we entred upon a far more difficult task, viz. the Anatomy.

Thomas Willis, Cerebri Anatome, 1664

Richard Lower (Fig. 1) was born in 1631 and was 1 of 3 sons of an old Cornwall family. He studied at Westminster School in London and in 1649 was admitted to Christ Church College, Oxford University, from which he received a Bachelor of Arts degree in 1653, a Master of Arts degree in 1655, and a Doctor of Medicine degree in 1665.6 Lower moved from Oxford to London to establish a medical practice at the request of the Archbishop of Canterbury in 1666. Lower was elected to the Royal Society in 1667 and was nominated as a candidate for entry into the Royal College of Physicians in 1671 and then elected as a fellow in 1675, the same year as Sir Thomas Willis’ death.6 Consequently, after the death of Willis, Lower was recognized as the leading physician in London and was appointed as Court Physician to King Charles II. “Among others in Oxford during these years were Thomas Willis, Robert Boyle, Robert Hooke, Christopher Wren, and Thomas Millington.”8 Lower identified with the Whig party due to his strong Protestant and anti-Popish position, and thus in the 1680s, with the fall of the Whigs and the rise of King James II, Lower subsequently lost royal favor and his court position.2 On January 17, 1691, after helping to extinguish a fire in London, Lower developed and died of pneumonia at the age of 60.4

During the 17th century, most scientific discoveries were inculcated with the accepted historical religious
and political beliefs and practices. The dominant view in medicine in this century strictly followed the traditional teachings of Galen (130–200 AD). However, many centuries later, William Harvey (1578–1657) used evidence to describe his observations rather than accepting historical principles. Lower’s first major influence came from Harvey, who had accurately described the circulation of blood and the mechanisms of the heart. Lower’s admiration and respect for Harvey are none more evident than in Lower’s own words:

...there are points not mentioned in Harvey’s circulation which need consideration...Harvey himself, indeed, seems to promise further contributions, had age and time allowed...I have myself tried to fulfill the promises of that excellent man, and to bring nearest to completion than they have hitherto been.12

One characteristic of Lower commonly documented was his loyalty to his predecessors, including Harvey and Willis. Richard Lower faithfully defended and expanded on Harvey’s basic principle of experimentation leading to scientific discovery, accepted as the scientific method. As Lower’s career progressed, he became increasingly well-known for his dissecting skills. Lower’s precision with experimental dissections allowed him to become an eminent contributor to medicine in England. Donovan wrote in 2004 of Lower:

He [Lower] did this by precise anatomic dissection and extensive experimentation, utilizing surgery as a technique in his investigations. He deserves recognition as the first surgical experimentalist of the modern medical or post-Harvey era.9

Lower, accompanied by his expert scalpel, was introduced to his second mentor, Sir Thomas Willis (1621–1675), a scientist at Oxford, whom he served for a period of time as his assistant.9 Lower proved his interest resided in 2 main areas: the function of the cardiopulmonary system, and neuroanatomy. As a heralded dissection and anatomist, Lower brought his “extraordinary dissection skills to Willis’ work of the nervous system and cerebral circulation.”6 It was this partnership with Willis and several others that provided Lower with his greatest impact on medicine, and thus will provide the focus of this report. As James O’Conner has stated: “Willis’ astonishingly insightful forays into the anatomy and physiology of the brain were extremely influential. His mark was indelible and represented a watershed in the development of the field.”14 Eventually, Willis’ mark accompanied the label of “Father of Neurology.”16

Contributions to the Nervous System

In an era in which experimentation was not required—and not well practiced—to unlock the mysteries of the human body, Richard Lower exemplified skill and intellect beyond his years. He supported, and in some ways fought for, the idea of experiments in science and became a master at identifying uncharted territories. Lower worked closely with Willis and contributed considerably as Willis completed Cerebri Anatome (Fig. 2). Over several years, Lower eventually published 3 distinguished manuscripts, which rightfully defined his endowment to English society in the 17th century and beyond.

Cerebri Anatome

Luckily, “Willis recognized the importance of method in studying the brain.”14 In 1665, Willis was so captivated by Lower’s expert craftsmanship that he immediately hired Lower to work in his lab, as there were few accomplished dissectors in the 17th century. Lower and Willis both had an interest in neuroanatomy and both determined that, to outline the brain in exquisite detail, the brain must be dissected with careful attention to delicate structures, hence the importance of highly experienced hands (Fig. 3).

The Cerebri Anatome, published in 1664, was Willis’ work that described the neurological structures and functions of the brain. O’Connor writes, “previous anatomists were let down by ‘flawed techniques, producing artifactual results.’”14 Willis knew that dissection was a critical step in producing accurate images and trusted Lower’s expertise. In a divergence from traditional methods of in situ dissection, Lower approached the brain from below,
removed it from the skull, and then sliced it from the inferior end upward. It is widely documented that Lower helped extensively with brain and spinal cord dissections for inclusion in *Cerebri Anatome*.16 It is remarkable to think that Lower successfully dissected an unfixed brain given the poor condition of each specimen and that they were performed “in the back rooms of houses and inns.” By studying these unfixed brains, Willis, with the help of Lower, reclassified the cranial nerves, superseding Galen’s description. Additionally, “together with Richard Lower, he [Willis] demonstrated their [cranial nerves] functions by ligating them in dogs.” He recognized the first through the sixth cranial nerves as we know them today. The seventh nerve he recognized was the auditory nerve with 2 branches. The eighth nerve he recognized was the vagus, and he recognized its branches to the heart.”13 According to Molnár, Willis, with the expert aid of Lower, correctly identified many of the cranial nerves, certainly an important achievement in neuroanatomy. Once the specimens were separated and identified by Lower and Willis, Wren would examine them through a magnifying glass allowing for a precisely drawn image (Fig. 3). Some also credit Lower with drawing “elegant figures of the brain and charts of cranial and autonomic nerves...” In his book, Carl Zimmer reported that in 1663 Lower “drew up diagrams of the nervous system.” These diagrams, together with the images produced by Wren and Lower, were used to complete the *Cerebri Anatome*.

Another of Lower’s contributions to neuroscience was the experiment he performed with Willis on dogs to prove that the control center of the heart was the hindbrain. They tied off the nerves that were transmitted from the hindbrain to the heart and the heart “quickly engorged with blood and died.” When Willis and Lower were experimenting with seizures, Lower frequently wrote to Boyle with excitement that he had illustrated and written of many diseases of the brain with astonishing observation and case studies. Willis received credit for the discovery of the arterial circle at the base of the brain named the circle of Willis. However, Lower was interested in the function of this circle and designed an experiment to determine if there was...
collateral circulation between the 4 main arteries. Wren and Lower performed dye injections on humans because previous injection studies on animals immediately after death demonstrated that blockage of just 1 of the cerebral arteries would not lead to sudden death.14 “Lower is credited with establishing that circulation through this arterial circle in the cerebral circulation named for Willis could be maintained even if three of the four contributing arteries were ligated.”4

It is difficult to determine the exact extent though which Lower contributed to Cerebri Anatome, but one thing is for certain: Willis generously recognized Lower’s integral contributions to his scientific contribution. In the treatise’s introduction of Cerebri Anatome, Willis celebrated Lower as “a most Learned Physician and highly skilful Anatomist.”17,18

Vindicatio

Lower wrote Vindicatio in 1665 as a harsh retort to Edmond O’Meara, who attacked Willis for his Harveian approach to research. This publication provided a strong statement in favor of the scientific method and provided foresight into the direction medical research would take in future centuries. Many renowned scientists agreed that the use of experiments would provide the most powerful method for identifying new discoveries. Lower was credited with assisting in the preparation of Cerebri Anatome, but only after he published Vindicatio, which defended Willis’ work on fevers.1

Although Willis occasionally used unsubstantiated theories to explain some phenomena such as “spirits,” the majority of his work followed a similar pattern of the modern day scientific method, by using either dissections or clinical cases of patients to describe functions of the body. Early on, Lower followed Galen’s theory, but later relied on empirical data to explain certain anatomical and physiological functions of the body. Empiricism was not often cited by leading scientists until the later part of the 17th century.14

Tractus de Corde

Lower’s ground-breaking research in physiology led to the publication of Tractus de Corde in 1669 (Fig. 4). In 1666, Lower became the first to transfuse blood from an animal into a human, despite failed efforts in the early 1600s. It was through the publication of Tractus de Corde that Lower gained his greatest recognition and in many respects caused the unintentional oversight of his contributions to neurology. It is noteworthy to realize his conclusions were based on precise anatomical dissections, autopsy studies using Willis’ deceased patients, clinical observations, and animal experimentation.4 Zimmer20 claims that Lower “…clearly established himself as a scientist” as a result of this publication.

De Catarrhis

Lower’s last major publication was De Catarrhis in which he attempted to challenge a widely held belief regarding CSF formation and origins of nasal catarrh. It is believed that this concise piece was published in 1670, complementing the second of several editions of the Tractus de Corde. In 1672 this work was eventually published independently, and not until 1963 was an English translation completed.4 Lower’s investigational experiments into how CSF was formed and how it circulated led to the discovery of hydrocephalus. “Lower’s book, is of historical significance because it was the first scholarly attempt by an English physician to take a classical doctrine and to disprove it by scientific experiment.”3 The Humoral theory widely held that sweating or micturition would correct an excessive accumulation of fluid in the body. If not allowed to perform one of these functions, it was believed that catarrh would be released from the overloaded cerebral ventricles from the pituitary stalk and these would exit through the cribiform plate into the nasal cavity. Lower, however, suspected that this was not an accurate description as he had done extensive dissections of the brain. He designed an experiment in which he injected “milk or a
black substance” into openings in the base of the brain, but neither flowed through the cribriform plate. Lower established through cerebral vascular infusions and other studies that there was no communication between the subdural space and the nasal passages. He then ascertained that particles passing along the olfactory nerves from the nasal cavity would provide a sense of smell to the brain. “An astute observation indeed,” claimed John Felts in 2000.

Dissension

As is the case in many historical documents regarding scientific findings, most are infected with dissension in determining the rightful recipient of credit. Appropriately, there is intrigue into the proper origin of the results from Willis’ Cerebri Anatome. “Some have attributed the results of Willis’ anatomic and physiologic studies to Lower, rather than to Willis.” Generously acknowledging the contributions of Lower to Cerebri Anatome, Willis wrote:

...Richard Lower, a doctor of outstanding learning, and an anatomist of supreme skill. The sharpness of his scalpel and of his intellect. I readily acknowledge, enabled me to investigate better both the structure and functions of bodies whose secrets were previously concealed...in a short space of time everything about the cerebrum and its appendage within the skull seemed clearly revealed and thoroughly explored by us...when we were entering upon a much more difficult task, the dissection of the nerves, the really wonderful dexterity of this worker and his untiring perseverance were conspicuous in the extreme...

Perhaps it was this recognition that prompted the controversy concerning Willis’ role in the research that led to the publication of Cerebri Anatome. Anthony Wood (1632–1695), a contemporary Oxford diarist and historian, questioned the intellectual contribution of Willis compared with that of Richard Lower, and wrote in Athenae Oxonienses, “Whatsoever is Anatomical in that book [Cerebri Anatome], the glory of belongs to the said R. Lower, whose indefatigable industry at oxon (Oxford) produced that elaborate piece.” It appears though, the most forceful criticism came much later from Sir Michael Foster (1836–1907), the distinguished Cambridge physiologist, who also believed that Lower had been the creative genius behind Cerebri Anatome. He declared that Lower was “the henchman of the fashionable Willis whose false name in large measure rested on Lower’s careful, unacknowledged work.”

However, not all authors agree that Lower was the true mastermind behind Cerebri Anatome. Sir Charles Sigmund claimed that Wood received his information from a biased source and that there never appeared to be any discord between Willis or Lower. Another dispute over Lower’s contributions came from Henry Stubbe (1632–1676), a philosopher and physician in his own right, who published numerous papers about the Royal Society. He credited Willis for many of his contributions to medicine and acknowledged Lower as the likely owner. However, in a minor section of the same manuscript, Stubbe writes, “…although Lower did the dissections, Willis’s was the master mind which inspired and directed the work.”

Furthermore, some authors discredit Lower for his explanation of catarrh. In fact, Edwin Clarke explained that Lower was not the first to identify that the nasal passages did not directly connect with the intracranial cavity. The original theory, found in Hippocratic writings and further solidified by Galen, was first criticized during the earlier 17th century. Jan Baptist van Helmont’s Catarrhi deliramenta in 1650 denied the existence of catarrh, especially from the brain. Also, Karl V. Schneider refuted the presence of any connecting channels between the brain and nasal cavity in his piece De catarrhis in 1664.

“Lower stood in Willis’ shadow for a decade...He discovered a spring near the village of Astrop that spurted water with healing powers...but Willis got credit for its discovery.” Lower never appeared to be resentful as Willis provided him with a solid foundation in science and a successful medical practice. Indeed he took full advantage of the teachings of Willis, which allowed him to become a well-respected physician in the Royal Society and many regarded him as the leading physician of his time. T. M. Brown quoted Anthony Wood as saying Lower was “esteemed the most noted physician in Westminster and London, and no man’s name was more cried up at court than his.” Perhaps Lower’s brilliant career as a scientist might have been overshadowed by his prominent success as a practicing physician.

Inarguably, Richard Lower played an integral role within society by both treating patients with high regard and researching inaccurate principles within the disciplines of medicine and neuroanatomy in particular. Lower ascended the ranks within England to become a very reputable physician as a member of the Royal College of Physicians, where he enjoyed a period of high praise. “Fame may have diverted his attention from further research and scientific inquiry as he did not publish any major works after De Catarrhis. However, (Tractus) De Corde did go through seven editions with significant changes, suggesting that Lower continued to perform some research.”

There may be some disagreement as to the crediting of certain discoveries within the scientific field. Nevertheless, it is accepted that Lower worked closely with Willis for several years, assisting with dissections and insight. In addition, history books illuminate the 3 major publications by Lower and give some insight into the impact each has had. As most articles in the literature emphasize, Lower had a marvelous career with numerous, novel discoveries. This is best exemplified in the following citation from Woo and Fung:

Yet Lower undoubtedly belongs in the pantheon of the greatest physicians. His life and work paint a portrait of a passionate and non-conforming mind. These characteristics helped him challenge tradition and make major contributions in anatomy and physiology, bringing great acclaim in his lifetime.

Although this latter excerpt does recognize Lower in a well-deserved manner, it appears that many authors have omitted a significant portion of his work in neuroanatomy. Despite the strongly held traditions and theories of his day, Lower did not conform, rather he challenged each scientific element that seemed erroneous. This led him to many revolutionary breakthroughs within the disciplines of anatomy and physiology. The discovery of the true origin of catarrh, the dissections and diagrams of the brain coupled with scientific experiments, and the carotid/vertebral col-
Richard Lower

lateral circulation, should shed light on a highly neglected component of Lower’s illustrious career. His willingness to challenge widely accepted beliefs to uncover many unimaginable truths within multiple aspects of medicine is truly his legacy. It is a legacy that defines him as an accomplished anatomist and physician during the 17th century.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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