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Profiles in Cardiology

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Sir Leonard Erskine Hill

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Sir Leonard Erskine Hill (Fig. 1) was born in Tottenham, England, on June 2,1866. Of the numerous eponyms associated with the physical findings of aortic insufficiency, it is enigmatic that Hill's sign, one of the most reliable, is the least known. Sir Leonard Hill first described his "reversed brachiopedal systolic gradient sign" in 1909[1] and further embellished it in 1911.[2] Hill had already found that in young healthy men in the horizontal position there was no difference in the arm and leg blood pressures. However, it was a colleague of Hill's, Dr. W. Holtzmann at the London Hospital Medical School, who first noted the arm-leg blood pressure differential in cases of aortic regurgitation. Holtzmann, at Dr. Hill's behest, was making some independent blood pressure measurements. He ascertained the pressures in several cases of aortic regurgitation and "found a noticeable difference between arm and leg readings in such."[1] After further study, Hill and Holtzmann confidently concluded, "a difference between arm and leg readings is most marked in all cases of aortic regurgitation, and when such patients are lying quiet in bed this difference is a diagnostic sign of aortic regurgitation."[1] Frank compared the measured popliteal-brachial systolic gradient with the degree of aortic regurgitation found at catheterization and surmised that Hill's "neglected bedside sign proved the most useful clinical index to the severity of aortic regurgitation."[3]

While Hill's sign may be his legacy, it was a bit player nestled among a multitude of more heralded contributions to physiology. These were made all the more magnificent in view of the fact that he had no formal training in physiology, limited training in the sciences and "never took his M.D., and it was not until the University of Aberdeen made him an honorary LLD in 1931 that he was strictly entitled to call himself "doctor.'"[4]

Education was highly valued in the Hill family. Leonard Hill's great-grandfather, Thomas Wright Hill, became a schoolmaster by simply purchasing a school in Birmingham, England. With family involvement, the Hazelwood School "developed on lines which anticipated the most advanced schools of today and in the 1820s it reaped an international fame."[4] In 1833, the school was moved to Bruce Castle, England, where Leonard was born in 1866. There, Leonard conducted his first scientific experiment, "dropping the family cat out of the window to see if it would really fall on its feet."[4] Hill's father, George Birkbeck, presided over the school until 1877, when it was sold. Birkbeck went on to literary fame, "known for his scholarly and accurate editing of Boswell's *Life of Johnson* and of other eighteenth century works."[4] Leonard aspired to be a farmer. However, Birkbeck was in the habit of telling his three sons what profession they would enter. The oldest, Maurice was allotted the Bar and subsequently knighted for his work as a judge. Norman, the middle son, became a solicitor and was made a baron for his success and "influence in directing British shipping policy in the first world war."[4] Leonard was directed toward medicine. Curiously, Birkbeck, despite his background in education, seemed unaware that medicine required any special educational background. Leonard was sent to Haileybury College and in his own words was "given an ordinary classical education and no scientific, and unfortunately, very poor mathematical training."[4] He never did practical work at the laboratory, received not even the "remotest knowledge of science and if he excelled at anything, it was, in his own judgement, as a forward on the Rugby football field."[4]

Entering medical school at University College, London, in 1885, he had a rocky start when a professor of zoology laughed at his first attempt to draw a diagram of a frog dissection. Nonetheless, he began to excel in his studies, winning the Bruce gold medal for surgery and medals in anatomy and physiology. (He sold the medals and purchased a painting with the proceeds.) He then gained experience as house surgeon at University Hospital College and qualified for his London M.B. in 1890. Shortly thereafter, he was inspired by a lecture

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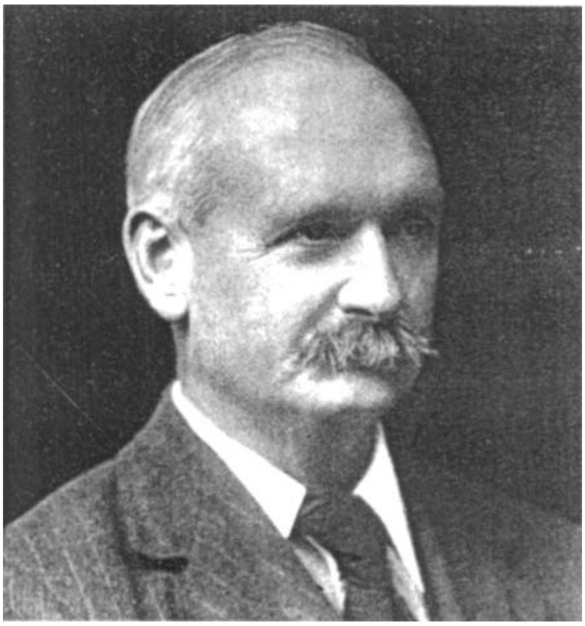

FIG. 1 Sir Leonard Erskine Hill (1866–1952). (*Source:* Obituary notices of Fellows of the Royal Society of London 1952–53;21:8.)

delivered by a visiting professor from Oxford, Sir John Burdon Sanderson. So captivated was he by this presentation that he wrote a letter to his future wife delineating three avenues for his professional career. The choices were those of a traditional medical consulting practice, to set up an office in a poorer part of London, or to devote his life to medical research—"the path which saves the millions when found."[4] He chose the latter, received the Sharpey Scholarship at University College and began to study under the famous physiologist Edward Schafer, finally getting some directed experience in physiology. He completed his studies, then briefly taught at Oxford and returned to University College in 1891 as assistant professor. In 1895, he was appointed lecturer in physiology at London Hospital.

His initial research concerned the circulation, primarily the cerebral circulation. He published his first book in 1896, entitled *The Physiology and Pathology of the Cerebral Circulation*. He then directed his research toward influences on the blood pressure. In collaboration with H.L. Barnard, they developed the armlet method of blood pressure measurement. This paper, initially rejected for publication by the Royal Society since it was "only an account of an instrument,"[4] was later published in the *British Medical Journal*. This delay cost them some recognition, for in the interim in 1896 the Italian Scipione Riva-Rocci reported on his sphygmomanometer. Hill and Barnard did refine Riva-Rocci's model in 1897 by the addition of a needle pressure gauge.[5]

Following his election to the Royal Society in 1900, he began to investigate caisson disease. He felt that with slow uniform decompression the bends could be prevented. Using themselves as subjects, Hill and his partner underwent successful decompression after exposure to six atmospheres. Their method was eventually replaced by Haldane's more efficient and safer staged decompression. In 1912, Hill published his second book, *Caisson Sickness and the Physiology of Work in Compressed Air*. He followed this work with many studies on the regulation of breathing and the effects of oxygen and is credited with being the first to design a bedside tent for the administration of oxygen. The intriguing finding that inhaling oxygen allowed a vocalist to sustain a note or trill led him to comment "that music, different in form from the usual, could be written for a singer who breathed oxygen first."[4]

Leaving London Hospital in 1914 to become Director of the Department of Applied Physiology in the National Institute of Medical Research, Hill began the most influential phase of his career, investigating the health of workers and the environment. His work was interrupted in 1916 by a second bout of tuberculosis (the first infection was in 1904), again requiring a lengthy convalescence. His research interests covered a wide spectrum of issues such as the health of munitions workers, the diet of the population, ozone, the ventilation of dug-outs, the medical aspects of gas warfare, and the influence of temperature, humidity and air movement on human comfort and health and work capacity.[4] To study the latter, he developed the kata thermometer, a device with which he "endeavoured to get in a single figure the cooling power of the environment from convection, radiation and evaporation."[4] He did extensive fieldwork and published prolifically in the arena of what we today might call occupational health. His magnum opus, *The Science of Ventilation and Open Air Treatment* was published in three parts in 1919, 1920, and 1923. In an effort to make his research more accessible to the public, he wrote *Health and Environment* in 1925, "emphasizing the benefit that would result to national health from closer attention to ventilation indoors, the prevention of smoke pollution out of doors and, more generally, from an open air life and proper food."[4] He resigned from the National Institute in 1930, the same year he was made a Knight. He finished out his scientific career as director of research at the St. John Clinic and Institute of Physical Medicine, examining the effects of ultraviolet and infrared rays, actually refuting some of the extravagant claims as to their therapeutic efficacy.

If there were a cloud over his career, it would have cast its shadow upon some of his early work on the cerebral circulation. Since 1783, the Monro-Kellie doctrine had held sway, stating that due to the incompressibility of the cranium, the volume of blood in the brain was always constant although blood flow may vary. In 1890, Roy and Sherrington, through experimental demonstration coupled with brilliant and perceptive reasoning, concluded, "the blood supply of the brain varies directly with the blood pressure in the systemic arteries."[6] They also reported, "the brain possesses an intrinsic mechanism by which its vascular supply can be varied locally in correspondence with local variations of functional activity."[6] Recall that Hill published his book on cerebral circulation 6 years later in 1896, which "rejected all previous work as being based on fallacious methods."[6] It was felt that Hill had failed to evaluate his own methods critically, failed to indicate clearly how he reached his conclusions, and was using techniques "peculiarly unsuited to discovering evidence for intrinsic circulatory control of the brain. . . and rebuked those who, with better methods or more sagacious reasoning, found evidence for its presence."[6] Others were even less benevolent in their denigration of Hill's studies with such remarks as, "Occasionally while tracing the development of ideas one must take into account work that retarded rather than contributed to their progress."[7] Hill's studies, "propounded with force and authority," overshadowed the work of Roy and Sherrington and dominated the field for some 20 years before being refuted in the late 1920s.

A proper description of Hill's sign is in order. His method was to place an armlet (blood pressure cuff) around the upper arm and another just below the knee. The cuff was then inflated and maximum systolic pressure was deemed to be the point of palpable disappearance of the radial pulse. For the leg, the obliteration of the stronger of the dorsalis pedis or posterior tibialis pulse was the index for the systolic pressure. These measurements taken in healthy young men while standing "differ by the hydrostatic pressure of the column of blood, which separates the points of measurements."[2] In the supine position, there is little or no difference in the values. While lying down, if the leg pressure is 20 mm of mercury greater than the arm pressure, aortic regurgitation should be suspected. Hill's sign is highly sensitive, but other conditions that are associated with decreased systemic vascular resistance such as thyrotoxicosis, sepsis, arteriovenous fistulas, beriberi, pregnancy, and strenuous muscle exertion may create false positives.[8,9] Aortic stenosis and occlusive peripheral vascular disease may cause false negative results. Patients with mild (1+) aortic insufficiency may have gradients less than 20 mm of mercury.[10] Those with atrial fibrillation and irregular R-R intervals may give erroneous results.[9] The pathophysiology of the sign is not well understood. The summation of the rebound wave returning from the periphery and the aortic pressure pulse may in part explain the phenomena since it is only noted with indirect blood pressure measurements.[9] Sapira *et al.* reported that 84% of the standard textbooks of medicine and cardiology they consulted did not mention Hill's sign.[10]

Despite the breadth of his research interests, Hill led an active and imaginative life beyond the scientific realm. He was a practitioner of his own advice regarding the benefits of fresh air and living a healthy life. Each morning at six he would bike through the Epping Forest to swim in a forest pool.[4] He was an accomplished artist and founded the Medical Art Society in 1935. After befriending a Japanese artist, many Japanese sought him when they visited London. This resulted in three successful exhibitions of his paintings in Japan, where his painting of a turkey created quite a sensation.[11] The *Dictionary of British Artists* noted that he exhibited eight pieces of art with the International Society, three with the London Salon, two with the Royal Society of British Artists, one with the Royal Institute of Painters in Water Colours, and two with the Royal Institute of Oil Painters (Nelson M: Personal communication. Letter from Oxford, England, August 13, 1999). After the death of his eldest daughter in 1929, their grandchild came to live with them, which inspired him to write a collection of stories published as *The Monkey Moo Book*. He had previously penned and illustrated a collection of fairy tales entitled *The Scarecrow and Other Fairy Tales*. *Philosophy of a Biologist*, the last of 10 medical books he published, was a "small book of somewhat disjointed reflections on what his life and scientific studies had taught him."[4] His obituary in the *British Medical Journal* mentions this book as a "work which would not please the orthodox Christian, nor, indeed, the upholders of any religious dogma, but he declared that modern science had brought us to the conception of a power, eternal, infinite, unknowable."[13]

Vigorous until the end, Hill died suddenly of a cerebral thrombosis at age 86 on March 30, 1952, survived by his wife and four of his five children. "Though his speech was incisive and he was inclined to be dogmatic, and in his laboratory and lecture theatre he could be rather forbidding," his friends remembered him fondly, remarking that "his broad and genial humanity soon became perceptible, illuminated by the warm affection of his colleagues and assistants."[13] In an era of high technology medicine, it is fitting then that we should pay homage to a "great-hearted gentleman who loved in equal measure science and humanity,"[13] who also described a simple bedside test for aortic regurgitation that is the only "known reliable predictor of the degree of the murmur."[9]

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