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Profiles in Cardiology

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Alonzo Thrasher Keyt

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The sphygmograph (literally “pulse writer”) was introduced in the early 1860s by Parisian physiologist, Etienne-Jules Marey. An instrument for recording physiologic events over time, the sphygmograph was one of the first “time and space machines of medicine.”¹ The excursions of the radial pulse were transmitted by levers and springs from a sensor pressed upon the artery to a stylus which recorded the pulse waves on a moving strip of smoked glass or paper. By 1870, a few elite American physicians were beginning to use European sphygmographs. Most were content to purchase commercial instruments, correlating waveforms with suspected structural and functional cardiovascular abnormalities. For physicians eager to embrace new technologies, the sphygmograph promised to revolutionize clinical cardiology by revealing the secrets of the heart and vessels.

America's greatest champion of the sphygmograph was Alonzo Thrasher Keyt (1827–1885), a native of Higginsport, Ohio, and an 1848 graduate of the Medical College of Ohio (Fig. 1). Keyt, who supported his large family as a general physician in Walnut Hills, a small community outside Cincinnati, was described as “sedate, almost grave, slow and deliberate in action, in accordance with the Dutch blood coursing in his veins.”²

Keyt began his investigations in 1874 with a simple sphygmoscope consisting of a calibrated glass tube rising from a fluid-filled reservoir at the base. The reservoir, covered by a thin rubber membrane, was pressed over an artery. He demonstrated to colleagues “the beautiful undulations in the glass tube caused by pulsations of the artery.”³ Keyt's first sphygmo-

graph was a bifurcated hydraulic instrument combining the simple calibrated glass column on one arm and a sphygmograph of his own design on the other (Fig. 2). The Keyt sphygmograph consisted of a small reservoir capped by an elastic disc. A pin fixed in the disc moved a lever, the distal end of which inscribed the tracings. A clockwork apparatus was incorporated into the recording mechanism. The rubber-covered sensor, connected by tubing and stopcocks to the arms of the instrument, could also be placed over the cardiac apex, thus recording a “cardiogram.”⁴

In the vivisectionist tradition of the day, Keyt conducted animal experiments. For example, he removed the ventral shell of a turtle to study the waves of the exposed beating heart.⁵ He also studied normal infants, correlating pulsations of the fontanel with the heart beat and pulse. Capitalizing on a popular craze for distance walking, he found that the pulse of “the champion pedestrian of the world” was always “equal to its work” and never “goaded to undue exertion.”⁶

Keyt's crowning achievement as an inventor of cardiac instruments was his elegant compound cardiosphygmograph,

FIG. 1 Alonzo Thrasher Keyt (1827–1885). Source: Ref. No. 13.

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FIG. 2 Keyt simple sphygmograph and tracing, with calibrated tube of sphygmoscope in collapsed position for transport. Source: Ref. No. 4.

introduced in 1877 (Fig. 3). When combined with a chronographic attachment, this apparatus allowed simultaneous transcription of the cardiac impulse, arterial impulse (usually the carotid), and time intervals measured in fifths of a second (Fig. 4). To measure such short intervals precisely, Keyt developed a painstaking system using a calibrated compass.⁵ He applied his cardiosphygmograph to the determination of pulse-wave velocities between points in the arterial circulation. Perhaps hopeful that he had hit upon a useful technique for the early diagnosis of chronic cardiovascular disease, Keyt made the intriguing observation that “arteries stiffened by atheromatous and calcareous degeneration give a rapid pulse-wave velocity.”⁷

Keyt was particularly interested in what he called the “pre-sphygmic interval,” the brief period between ventricular contraction and opening of the aortic valve. The interval was determined by measuring the interval between ventricular contraction and carotid pulsation on simultaneous tracings, then subtracting the trivially small aortic valve to carotid inter-

val. Keyt found that the presphygmic interval was prolonged in patients with mitral insufficiency, aortic stenosis, and aneurysm of the aortic root. In one young man with all three disorders proven at autopsy, Keyt documented an “enormous delay of the pulse.” Thus, he declared, “step by step, as correct graphic phenomena are connected with well ascertained pathological conditions, will the science of clinical sphygmography be built up.”^{8,9} Only a few men in Europe and none in America applied the sphygmograph to such quantitative studies. In a series of articles published in local, regional, and national American medical journals, Keyt described the construction and application of his cardiosphygmograph. The first volume of the *Journal of the American Medical Association* (1883) featured no less than four full-length research articles by Keyt.

From the mid-1870s until his death in 1885, Keyt applied his system to the study of patients with cardiac or vascular disease. Anticipating a new partnership between clinical cardiology and cardiovascular technology, he wrote in 1882: “The diagnostic signs furnished by cardio-sphygmography go hand in hand with the evidences of auscultation and percussion, correcting, extending, and completing the latter, and give to cardiac diagnosis unparalleled precision and perfection.”¹⁰

Keyt considered himself a colleague of Marey and his French disciples. Marey, who purchased a Keyt sphygmograph, praised the clarity of its tracings.¹¹ According to one memoir, “tidings of encouragement from men of high distinction in medicine,” reached Keyt from many European cities.¹² Keyt’s son-in-law and sole American disciple, Cincinnati physician Asa Brainerd Isham, wrote a laudatory memorial of this American pioneer of the sphygmograph. “In the pursuit of his research,” wrote Isham, “Keyt spent thousands of dollars, he suffered much pecuniary loss by forgetfulness of calls, and he shortened his life by his assiduous labor. . . . But he counted not his work for gain. He wrought from a pure love for science, and was happy when he brought to light a new fact for the information of the profession and the world.”¹³ Keyt was tireless in pursuit of his sphygmographic investigations, hunting through hospitals for suitable patients and watching mortality lists to confirm his findings by autopsy.¹²

Keyt’s work, despite a score of articles published in New York and Boston medical journals, “remained singularly unnoticed by [his] countrymen.” In America, only Nathan Davis

FIG. 3 Keyt compound cardiosphygmograph with built-in chronometer, showing simultaneous tracings from apical and arterial sensors. Source: Ref. No. 6(a).

FIG. 4 Typical chronocardiophysgmographic tracing (on smoked glass) with time intervals (A, B, C) marked by Keyt. Source: Ref. No. 6(b).

of Chicago, first editor of the *Journal of the American Medical Association*, praised Keyt's research as an "ingeniously conceived, patiently executed, and logically considered series of experimental investigations. . . ."¹² Unlike many other sphygmographers in America and abroad who quickly grew disenchanted with the sphygmograph, Keyt never lost faith in his instrument and his methods. In his last published article, which appeared in the *Journal of the American Medical Association* in 1885, Keyt continued to hold out great hope for simultaneous cardiophysgmography.¹⁴ He died suddenly in 1885 at age 58 of "cardiac paralysis" brought on prematurely, according to Isham, by overwork.¹⁵ Shortly after his death, Keyt's published works were collected into a single volume, available today in archival collections.⁶

Keyt's cardiophysgmograph died with its inventor. Interest in sphygmography faded by the 1890s, as initially enthusiastic clinicians became disillusioned by the finicky instrument and the inconsistent correlations between pulse tracings and clinical or pathological findings. Physiologically inclined physicians turned briefly to the polygraph, a combined sphygmograph and venous pulse-wave recorder invented by English cardiologist James Mackenzie. By analyzing simultaneously recorded arterial and venous tracings, Mackenzie elucidated the mechanism of several cardiac arrhythmias and speculated on the pathophysiology of congestive heart failure.¹⁶ The electrocardiograph and sphygmomanometer, introduced into clinical practice early in the twentieth century, proved to be far more durable and rewarding technologies.

Keyt, like his sphygmograph, has been ignored by historians of American cardiology. Nevertheless, he was a disciplined and innovative investigator, limited by the primitive state of medical technology and the nascent research environment of his day. He could not have known at the outset that si-

multaneous cardiophysgmography would prove to be a dead end. Keyt exemplified the spirit of private, unremunerated scientific inquiry, conducted in hours stolen from practice by busy clinicians, that characterized nineteenth-century American medical research.¹⁷

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