Profiles in Cardiology

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Frans C. Donders

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Professor Frans C. Donders was the first to record heart sounds indirectly. This was an important contribution to cardiology.

Frans Cornelis Donders was born in 1818 in Tilburg, The Netherlands. He attended Medical School in Utrecht and made his thesis in 1840 at Leiden University, Leiden, The Netherlands. At the age of 27 he became a Member of the Royal Netherlands Academy of Sciences and, in 1847, he was appointed Professor of Physiology at the University of Utrecht (Fig. 1). He turned out to be a pluripotent physiologist and was oriented mainly in metabolism, respiration, and ophthalmology; however, he also became interested in the physiology of the heart muscle, with a special interest in variations in the rhythm of the heart and the influence of the vagal nerve on it.

In the field of cardiovascular physiology, his most important work was on the rhythm of heart sounds. In a 1868 paper,¹ he described the duration of systole and diastole at various heart rates. He registered heart sounds in an indirect way. With his stethoscope he listened to the heart sounds of normal individuals and registered them on a rotating carbonized cylinder with a movement of his hand.

First he estimated the error of his method. He used a metronome as the standard of reference of regularity. Listening to the sounds of the metronome, he registered them on the cylinder and calculated the registered differences in regularity on the cylinder in over 1,000 observations. He found that his personal error was 1.25%.

Using his method of registering the rhythm of heart sounds, he detected that the duration of systole was rather constant: between 0.301 and 0.327 s, when the heart rate was between 75 and 100 beats/min. Even in cases of extreme bradycardia (< 30 beats/min), the duration of systole was not increased: it was 0.325 s. Only in tachycardia was the duration of systole shortened, but at heart rates under 100 beats/min the duration of systole was very constant. His findings have frequently been confirmed by direct phonocardiography; therefore, he is considered to be the inventor and first user of phonocardiography.

Using his indirect registration of heart sounds, Donders made interesting observations on the variability of the heart rate during respiration. In his experiments, he registered both respiration directly and heart sounds indirectly on the rotating carbonized cylinder after dissecting the vagal nerve in animals, and thus studied the influence of the vagal nerve on heart rate and respiration for the first time.

Later he developed the "physiological rheoscope." He connected the nerve of a nerve-muscle preparation of a frog with the beating heart of a dog. He observed that just prior to ventricular systole, the frog muscle contracted. He estimated the duration of this time lag at a 1/70 part of a second. By these observations he became the godfather of the pre-ejection period, later described in the era of systolic time intervals. Finally, with his physiologic rheoscope, he observed a second twitch of the frog muscle just after the end of systole and at the beginning of diastole. This second electrical change in the ventricle was later identified as the T wave in the electrocardiogram; therefore, Donders was also the founding father of ventricular repolarization.

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FIG. 1 Professor Frans C. Donders (1818–1891) in his physiologic laboratory at the University of Utrecht. Source: The University Museum Leiden, The Netherlands.

Many young investigators visited Donders' laboratory in Utrecht, among them Theodore Engelmann and Willem Einthoven (1860–1927), the developer of electrocardiography, for which he received the Nobel Prize for Medicine in 1924.

Although Donders made some unique observations in the field of cardiovascular physiology, his main experimental and clinical investigations were concentrated on ophthalmology. It is interesting that his most famous pupil, Willem Einthoven, did his thesis on ophthalmology in 1885.

In 1888 Donders suffered a minor stroke and his health deteriorated rapidly. The chair of physiology at Utrecht University was taken over by Theodore Engelmann. Donders died in 1891 in Utrecht at the age of 71. He will be remembered as the founding father of indirect phonocardiography, the pre-ejection period, and ventricular repolarization.

Reference

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