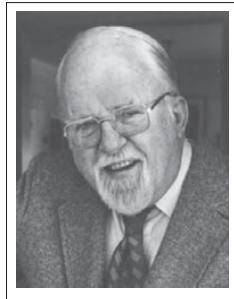


Norman J. “Jeff” Holter (1914–1983)

Automated systems of patient’s monitoring are widely used in cardiology, ranging from electrocardiography (ECG) recordings to multiparameter monitoring systems in critical care units. The early beginnings of ambulatory electrocardiography monitoring are inseparably connected with its’ inventor Norman Jeff Holter.



Norman Holter was born on February 1st 1914 in Helena, Montana. In 1931 he graduated from Carroll College in Montana and started studying at the University of California in Los Angeles. In 1937 he earned a Master’s degree in physics at the University of California, Los Angeles, and in a year a Master’s degree in chemistry from the University of Southern California. As he was a very ambitious person he didn’t finish his education at that point, completing postgraduate work at the University of Heidelberg (Germany), the University of Chicago, the Oak Ridge Institute of Nuclear Studies, and the University of Oregon Medical School. He spent the time during World War II as senior physicist in the U.S. Navy, working on ocean waves’ characteristics and headed a government research team testing a bomb at Bikini Atol. He was also involved in another national project with United States Atomic Energy Commission on hydrogen-bomb in Marshall Island [1]. Although he worked on bomb testing, he was against uncontrollable use of atomic explosion in military.

In 1947 Holter returned to his home town, Helena, where he formed foundation dedicated to public good — Holter Research Foundation (HRF). His foundation possessed Holter’s own car, laboratory and his house. While managing HRF he served as the president of the Society of Nuclear Medicine (1955–1956) and was a full professor at the University of California in San Diego from 1964. It should be emphasized that the term “Nuclear Medicine” to name the specialty dealing with radionuclides was first suggested by Holter and replaced previously proposed “Atomic Medicine”, “Isotope Medicine” or “Isotopology” [2].

Holter was a man of many interests including atomic energy, biophysics, chemistry, music, pho-

tography, and biotelemetry. Among his discoveries we can mention square raindrops, nuclear explosion detectors and one of the most important inventions in cardiology: long-term ambulatory ECG monitoring which is currently known as “Holter monitoring”. It was in the forties when Jeff Holter started working with Joseph Gengerelli on the stimulation of

nerves by alternating electrical fields. His initial interest in the electrical activity of human body led him to the idea of monitoring heart signals [3, 4]. The first device created by Holter was rather big. Initially (in 1947) it consisted of two heavy batteries and ECG radio transmitter, weighing together 38 kg (85 pound) which was rather inconvenient to be worn by a patient (Fig. 1). The technique of the examination was based on recording and transmitting ambulatory electrocardiograms by radio-electrocardiograph and audiovisual superimposed ECG presentation, which enabled faster reviewing ECG data [5, 6]. To become convinced of the usefulness of the ambulatory ECG in late fifties, Holter conducted research on 200 patients in Great Falls. The experiment was successful revealing some cases of exertional angina. The device and technique was first evaluated in 1961 by both, Norman Jeff Holter and his coworker — William Glasscock [6]. Besides the weight, it wasn’t free from other limitations, such as restricted time and range of measurement. To solve those problems Holter teamed up with Bruce Del Mar and together they manufactured smaller device which additionally has the possibility to high speed review and allowed longer than 24 hour recordings. It all resulted in manufacturing the first commercial device in 1962 by Del Mar Engineering Laboratories under the name Avionics Research Products Corporation. As the new diagnostic method was very popular among scientists and proved effective by publishing a vast number of research and clinical findings, by the 1955 it enjoyed a good reputation and was widely accepted by medical community. The most interesting fact about the beginnings of the technique of Holter monitoring was the fact that faster reviewing of recorded tracings was conducted with the use of radio, so it



Figure 1. The original Holter device from 1947, weighing 38 kg.

was read by sound. Smooth humming sound meant that it was sinus rhythm, whereas choppy sounds were the markers of ventricular extrasystolic beats. For a detailed look at the fragment of ECG that "sounded bad", it had to be stopped and played in real time. In general, speeding it up saved much time while recording cardiac activity during longer periods of time gave the possibility to capture a wider range of eventual abnormalities [7].

The technique of 24-hour ambulatory monitoring of ECG has evolved over the years. The device

enabled to review 24 hour recording in an hour (it played back fifty times in real times). Development in technology resulted in miniaturized portable tape recorders, speed up, simplified analysis and increased the number of channels to record and analysis. Recorders which are available nowadays support a solid state memory card (PCMCIA), miniaturized hardware, compression software and sophisticated analytic programs.

Holter monitoring is commonly used in every cardiology ward all over the world, that entails the fact that his name is still known from this device by a few hundred thousand physicians and patients. Once he said: "When my heart starts skipping, they'll have the longest normal base line in history" [2]. Among Montana's people Norman Holter was claimed to be "Renaissance man". Because he always remained dedicated to his state and according to his contribution to science, he received honorary doctorate degrees from Carrol College and Montana State University and there are numerous landmarks around Helena named after him. In recognition of his contributions to medical technology, in 1979 he was awarded with the Association for the Advancement of Medical Instrumentation Foundation Laufman-Greatbatch Prize.

References

1. Barold S. Norman J. "Jeff" Holter-"Father" of ambulatory ECG monitoring. *J Interv Card Electrophysiol*, 2005; 14: 117–118.
2. Brucer M. Norman "Jeff" Holter (1914–1983): A historical note and, as it must be, an obituary. *J Nucl Med*, 1984; 25: 132–133.
3. Kennedy HL. The history, science and innovation of Holter technology. *Ann Noninvas Electrocardiol*, 2006; 11: 85–94.
4. Holter N, Gengerelli JA. Remote recording of physiological data by radio. *Rocky Mountain Med*, 1949; 46: 747.
5. Holter NJ. Historical background and development of ambulatory monitoring. In: Jacobsen NK, Yarnall SR eds. *The nature of research, ambulatory ECG monitoring*. MCSA, Seattle, Wash. 1976: 1–9.
6. Holter NJ. New method for heart studies continuous electrocardiography of active subjects. *Science*, 1961; 134: 1214–1220.
7. Corday E. Historical vignette celebrating the 30th anniversary of diagnostic ambulatory electrocardiographic monitoring and data reduction systems. *J Am Coll Cardiol*, 1991; 17: 286–292.

*Joanna Gawłowska
Jerzy Krzysztof Wrancicz*

*Department of Electrocadiology
1st Chair of Cardiology and Cardiosurgery
Medical University of Lodz, Poland
e-mail: joanna.gawlowska@gmail.com*